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ABSTRACT

This guide, which is designed to be used in a two-course sequence, is intended to prepare college-bound high school juniors and seniors for engineering and related courses at the college level. The guide was developed as part of an experimental competency-based curriculum that integrates the high-tech applications of mathematics and science concepts into pre-engineering activities. The following topics are covered in the first course: the engineering profession and related careers; engineering graphics, descriptive geometry, and measurement; contributions of engineering in history; fundamentals of problem solving; the science and properties of materials; methods of working with different materials to solve problems; communication of technical information; use of the design process to improve devices or systems; research methods and use of technical libraries and patent information; computers and problem solving. In the second course, the course objectives are related to students and society as a whole, the concept of the technological team is reviewed, and a formal seminar on an engineering case study is presented. A program description, descriptions of the two courses, task/competency analyses for each of the two courses, and a bibliography are included in the guide. Appendixes contain lists of related information and resources, suggestions for advisory committees, career and educational information, a list of engineering projects and case studies, formulas and charts for student reference, a glossary of engineering terms, a laboratory facilities and equipment list, instructional materials (transparency masters, student handouts, and sample group projects), and an explanation of evaluation techniques (tests and performance/problem-solving exams). (MN)

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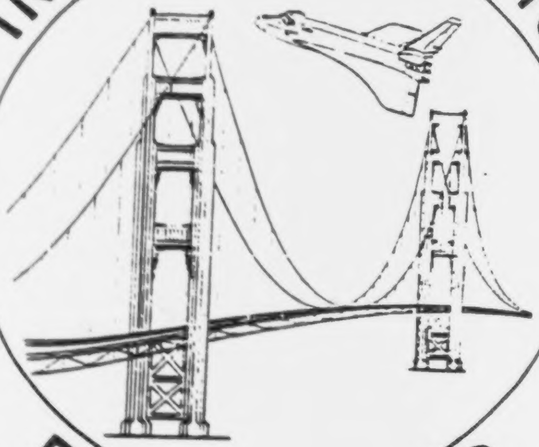
COURSE I:
CHALLENGES OF ENGINEERING

INTRODUCTION TO ENGINEERING



COURSE II:
ENGINEERING PROJECTS

PRESENTED
by

DR. LYNN P. BARRIER
VIRGINIA DEPARTMENT OF EDUCATION
AMERICAN VOCATIONAL EDUCATION CONVENTION

SAHARA HOTEL
LAS VEGAS, NEVADA
SATURDAY, DECEMBER 5, 1987

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A JUNIOR AT FAIRFAX HIGH SCHOOL
MR. MICHAEL STEPHENS, TEACHER

INTRODUCTION TO ENGINEERING CURRICULUM RESEARCH PROJECT

AGENCY RESPONSIBLE FOR THE DEVELOPENT OF THE CURRICULUM: Technology Education Service, Virginia Department of Education

TIME PERIOD OF THE PROJECT: July 1, 1984 to June 30, 1987

OBJECTIVES OF THE PROJECT:

1. Develop an experimental curriculum which will integrate the high technology applications of mathematics and science concepts into an introduction to engineering program of technology education.

2. Respond to our nation's need to motivate young people to pursue science, mathematics, and technology programs and careers.

CURRICULUM DEVELOPMENT PROCEDURES

An advisory committee was established composed of technology education teachers, curriculum specialist, teacher educators, supervisors, faculty of schools of engineering, community college personnel, NASA scientific personnel and engineers, and practicing engineers to advise the State Staff on project procedures and content of the curriculum. This committee (advisory team) first met together at NASA Langley Research Center for a week in the summer of 1984. The site was selected to take advantage of the engineering resources available and the services of the External Affairs Division at NASA.

Three teachers who were on the original curriculum research team, field tested the curriculum draft during the 1984-85 school year. They further developed the curriculum along with other members of the curriculum team. The first draft of the curriculum that the teachers experimented with included three basic areas of instruction: (1) Systems, (2) Problem Solving, and (3) Design. These areas seemed to be the three major engineering principles that our engineering advisors emphasized. Therefore each of the pilot teachers assumed one of the areas for instructional development.

The curriculum team and advisors continued to develop the competency task list based on engineering principles and practices. These were then put in the form of "Technology Learning Activities (TLAs).

In June, 1985 the curriculum team and invited consultants/advisors revised and validated competency tasks that had been previously developed for the first course. The team decided that the three areas of instruction previously selected and piloted the first year should be incorporated into the total program of instruction. It was determined by this time that the "Introduction to Engineering Curriculum" would require two sequenced courses rather than just one course in the program. The courses were titled "Challenges of Engineering" and "Engineering Projects". Therefore, the two courses became the program of "Introduction to Engineering".

The team also developed the inservice plan for preparing additional teachers at the June, 1985 sessions.

In August, 1985 thirteen additional pilot teachers were given inservice on the program. They further field tested the curriculum during the 1985-86 school year and continued to develop the curriculum with the help of advisors and the curriculum team.

The pilot teachers and curriculum team met again in June, 1986 along with additional advisors in the engineering field to revise and refine the first course and further develop the second course competency task list. Resource materials, textbooks, audio-visual materials, etc. were reviewed and selected.

In August, 1986 eleven additional teachers, one out of state teacher educator and two local supervisors were given inservice on the program. Some of these teachers were replacement teachers for school divisions that already had the program the previous year and teachers who implemented the program either in 1986 or 1987.

In the winter of 1987 a special writing team prepared the final draft of the curriculum. The curriculum resource guide was put in a "Competency Based Instruction" format with "Technology Learning Activities" and a lesson plan format was developed.

Inservice for teacher educators at each of the five institutions who prepare technology education teachers were given inservice on the "Introduction to Engneering Curriculum" in the Spring of 1987. All textbooks, resource materials, visuals, as well as the curriculum guide were issued to the teacher educators. Instruction for the program will be included in the preparation of technology teachers.

Virginia Tech University offered the first course in the "Introduction to Engineering" program in the Summer of 1987. Some graduate students at Tech took the course as well as one additional teacher who will be teaching the program in 1987-88 school year.

The "Curriculum Resource Guide for Introduction to Engineering" has been turned over to the curriculum center (June, 1987) for final editing and printing. Draft copies of the curriculum guide have been issued to the teachers, teacher educators, and certain curriculum team members.

The "Introduction to Engineering Curriculum" has been approved and course codes and standards for the program have been included in the "Program of Studies for Technology Education" in Virginia.

A slide/tape presentation "Engineering: An Introduction to the Field and its Careers", has been developed and is ready for use by the teachers. The presentation is in three parts and has a narration handbook with objectives for each part. A video tape is in the process of being produced and other visuals will continue to be developed.

A description of the typical facilities required for the program and the type of equipment needed is currently being reviewed and studied. It appears from a consesus of the curriculum team however, that having access to a comprehensive laboratory with a variety of equipment including testing and scientific instruments and a lab area for drawing, planning, and design are ideal.

The pilot teachers have an advisory committee at the local level composed of math and science teachers, local practicing engineers, and people in industry who assist the teacher with relevant engineering practices. This is highly recommended since it is a new field of instruction for technology education and the use of community resources is sound educational practice.

The program has been presented at state and national conferences during the past two years. Presentations on the program will be made at the Southeast Technology Education Conference in Atlanta, October, 1987; the American Vocational Association Conference in Las Vegas, December, 1987 and the International Technology Education Association Conference in Norfolk, March, 1988. Plans are also underway to prepare articles for professional journals.

The Technology Education Service Staff would like to thank the many people who have helped develop the project. We would also like to thank the superintendents of the various school divisions for allowing teachers to work with us to field test the curriculum in the schools. This project would not be possible without the cooperation of all of the people who have helped develop the curriculum. Acknowledgement of these people will appear in the final curriculum document.

Submitted by:

Dr. Lynn P. Barrier, Supervisor Technology Education and Director of the Curriculum Project
Virginia Department of Education
210 Church Ave. SW
Roanoke, Virginia 24011
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September 11, 1987

PROGRAM TITLE: INTRODUCTION TO ENGINEERING

DESCRIPTION:

Introduction to Engineering is a program designed to prepare students more effectively for engineering and related careers. The program integrates the high-tech applications of mathematics and science concepts into pre-engineering activities. The challenges of a career as an engineer, technologist, or technician are explored.

Instruction in Introduction to Engineering enables students to experience competencies relevant to engineering principles such as problem solving, materials processing, materials science, and the enterprise system resulting in occupational development useful to the future engineer, technician, technologist, and related career fields.

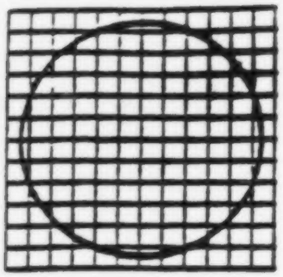
Program completers are prepared with competencies that will assist them in the future. The program will prepare students to enter employment in technically related fields or articulate for advanced preparation in community college or university programs.

SUGGESTED GRADE LEVEL: 11 - 12

APPROVED COURSE	VA COURSE CODE
CHALLENGES IN ENGINEERING	8490
ENGINEERING PROJECTS	8491

SUGGESTIONS FOR IMPLEMENTING THIS PROGRAM:

This program is designed to challenge the college-bound student. Usually these students have completed algebra, geometry, and may be taking trigonometry and physics along with one of these courses. A basic technical drawing course is suggested for other students prior to these courses.



CHALLENGES IN ENGINEERING

This course provides for orientation to the careers and challenges of engineering. Students are actively involved with high tech devices, engineering graphics and math/scientific principles through problem solving experiences. Activities are provided in descriptive geometry, materials science and technical systems. Students communicate information through seminars, technical reports and sharing ideas.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply Technology & Engineering to Life & Work	8490	11 or 12	1 maximum 1 period per day 36 weeks	None

SELECTED COURSE GOALS

Experiences and activities of this
TECHNOLOGY EDUCATION course will enable the student to:

1.1 discuss engineering careers, history, practices and concepts.
1.2 apply mathematical and scientific principles to technical problems.
1.3 assess abilities and interests as they relate to engineering and technician level careers.
1.4 communicate through oral, written or graphic means the results of solutions to problems.
1.5 select materials and processes appropriate to need.

2.1 calculate mathematical solutions with calculator.
2.2 use tools and machines necessary for processing materials or products.
2.3 use a computer to analyze data or to interface with practical application.
2.4 solve problems with mechanical and electrical systems.

3.1 display a positive attitude toward the value of engineering practices by citing their contributions to improving our world.
3.2 recognize the value of problem solving, research and development, and technical communications.
3.3 give examples of the value of mathematics and science to practical solutions.

CHALLENGES OF ENGINEERING

Suggested Task/Competency Sequence (8490)

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1. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD
   - 1.1 Discuss the effects of the explosion in scientific knowledge on the development of technology.
   - 1.2 Explain the pressing need for more engineers and technicians in the future.
   - 1.3 Identify the members of the technological team and justify its existence.
   - 1.4 Participate in group work and personnel system to manage class and laboratory activities.
2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS
   - 2.1 Summarize the professional characteristics of engineers.
   - 2.2 Outline the principal fields for specialization in engineering.
   - 2.3 Investigate the procedures for becoming a registered engineer in Virginia.
   - 2.4 Describe education needed for specialty fields in engineering and technology.
   - 2.5 Describe the opportunities gained through the study of engineering and technology.
   - 2.6 Establish a professional attitude toward classroom and laboratory activities.
3. APPLYING ENGINEERING GRAPHICS, DESCRIPTIVE GEOMETRY, AND MEASUREMENT
   - 3.1 Distinguish between various measurement systems and their basic units.
   - 3.2 Write a mathematical equation that is constant in units of measurement.
   - 3.3 Interpret drawings using various systems of measurement.
   - 3.4 Use the precision measuring tools and instruments to lay out, measure, and inspect parts or products.
   - 3.5 Measure quantities of materials and conduct tests accurately using SI units and U.S. customary Units.
   - 3.6 Use engineering design graphics and descriptive geometry in the solution of design problems.
   - 3.7 Sketch objects using multi-view and pictorial principles.
   - 3.8 Prepare drawings using basic technical drawing instruments for orthographic projections and isometric projections.
   - 3.9 Use graphs, empirical equations, mechanisms (kinematic representations), graphical mathematics, and nomography in the solution.
   - 3.10 Use graphical vector analysis in the design process.
   - 3.11 Build models that illustrate principle classes of physical models of new engineering creations from graphic solutions.
   - 3.12 Use computer aided design software (CAD) to prepare drawings.
   - 3.13 Use computer aided manufacturing software (CAM) to simulate a manufacturing problem.
4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY
   - 4.1 Recall the history of engineering from the beginning of civilization to the present day.
   - 4.2 Research an engineering achievement to prepare a model or display and a written report.
   - 4.3 Deliver a short oral briefing which explains a technical device or engineering achievement.
5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING
   - 5.1 Apply steps in the problem solving method or process (individual activity).
   - 5.2 Function as an engineer or technologist in problem solving activities.
   - 5.3 Apply mathematical formulas to problems and activities.
   - 5.4 Perform the keyboard functions on a scientific, hand-held calculator.
   - 5.5 Input computers and application programs when appropriate for problem solving activities.

6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS
    6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.
    6.2 Use tools, laboratory apparatus and equipment to safely determine the properties of materials.
    6.3 Conduct laboratory tests and report results in a written test report.
    6.4 List causes of failure in materials and give procedures used to prevent such failures.
    6.5 Explain the concept of supply and demand as it relates to materials in short supply.
    6.6 Experiment with processes used with metal, woods, polymer, ceramic, and composite materials and adhesives.
7. WORKING WITH DIFFERENT MATERIALS TO SOLVE PROBLEMS
    7.1 Function as a member of a team in problem-solving activities.
    7.2 Redesign and test a technical device in small groups.
    7.3 Use mathematical symbols to express a relationship between two or more variables.
8. COMMUNICATING TECHNICAL INFORMATION
    8.1 Examine engineering data and discuss the need for communication.
    8.2 Write a technical report (or proposal) for an engineering project.
    8.3 Use a computer for word processing technical information.
9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM
    9.1 Select a problem or project for improvement.
    9.2 List essential steps in the design process.
    9.3 Use the steps in the design process to improve a product.
10. RESEARCHING TECHNICAL LIBRARY AND PATENT/INVENTION INFORMATION
    10.1 Identify informational references found in a technical library.
    10.2 Locate reference books, dictionaries, and periodicals used by engineers.
    10.3 Discuss the six legal categories of patents.
    10.4 Explain how patents are obtained.
    10.5 Describe how patents protect the inventor.
11. COMPUTING DATA FOR SOLVING PROBLEMS
    11.1 Perform the keyboard functions on a scientific, hand-held calculator. (See task #5.4 for resource form.)
    11.2 Use computers and application programs when appropriate for problem-solving activities (should add more comoputer science here). (See task 3.12 for resource form.)
    11.3 Apply mathematical formulas to problems and activities. (See task 5.3 for resource form.)
    11.4 Use mathematical symbols to express a relationship between two or more variables. (See task 7.3 resource form.)
12. INTRODUCING THE TEAM CONCEPT AND THE ENGINEERING DESIGN PHASES
    12.1 Recall the members of the technological team and the steps in the problem-solving process.
    12.2 List the reasons and steps for a feasibility study.
    12.3 List the essential steps in the preliminary design phase.
    12.4 List the essential steps in the detailed design phase.
    12.5 Present overview of the group method to relate the importance of teamwork for problem solving.
    12.6 Brainstorm and select possible problem-solving activities for feasibility study.
13. BRIEFING OTHERS ON RESULTS OF ENGINEERING
    13.1 Present an oral report on problem-solving activities.
    13.2 Pre-register for competitive events.
    13.3 Prepare a written technical report on problem-solving activities.
    13.4 Construct a display of activities to use in public location.

ENGINEERING PROJECTS

This course emphasizes the applications and the design process of engineering. Students form engineering teams and select a group design project. Each team uses communications, graphics, mathematics, and community personnel to solve problems. Appropriate information is learned by each team in order to complete a project. Projects may be models, systems or products that creatively solve an engineering problem.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply Technology & Engineering to Life & Work	8491	12	1 maximum 1 period per day 36 weeks	Recommended as a follow-up to Challenges in Engineering

SELECTED COURSE GOALS

Experiences and activities of this TECHNOLOGY EDUCATION course will enable the student to:

1.1 work as an engineering team to select a problem related to engineering.
1.2 follow the engineering design process to design and build a solution, project, or model.
1.3 apply mathematics and science to solution of problem.

2.1 select and use resources, tools, machines, and materials in completion of a design solution.
2.2 use computers to design, control, or simulate engineering solutions.
2.3 experiment, test, and build a product, system, invention, or prototype.

3.1 work cooperatively in a group, both as a leader/manager, or as a team member.
3.2 discuss contributions and value of mathematics, science, and technology to the work of an engineer.
3.3 cite examples of ways by which engineering has improved society and the lives of people.
3.4 share and report information during seminars.

ENGINEERING PROJECTS

Suggested Task/Competency Sequence (8491)

1.RELATING OBJECTIVES OF COURSE TO STUDENTS AND SOCIETY
1.1 List courses that help an engineer work with, for, and communicate with people.
1.2 List ways an engineer can prevent his/her knowledge and skills from becoming obsolete.
1.3 Discuss the impact of engineering on society and the environment.
1.4 Identify appropriate community activities for engineers.
2. REVIEWING THE TECHNOLOGICAL TEAM AND RELATED CAREERS
2.1 List the members of the technological team and describe their responsibilities.
2.2 Describe the formal educational background of an engineering technologist.
2.3 Write the definition of an engineer.
2.4 Discuss ways that all engineers are managers.
2.5 List the levels of management wherein an engineer might work.
3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY
3.1 Identify and describe engineering problems and their solutions.
3.2 Describe the application of mathematics in the solution of engineering problems.
3.3 Describe the application of scientific principles in the solution of engineering problems.
3.4 Describe the application of technology in the solution of engineering problems.
3.5 Utilize tools, machines, and equipment safely.
3.6 Prepare a model of the solution of an engineering problem.
3.7 Use engineering graphics to describe the solution of an engineering problem.
3.8 Describe the social, cultural, and environmental impact of an engineering
3.9 Present an oral report on the solution of an engineering problem.
4. OBSERVING DESIGNS IN NATURE
4.1 Describe examples of products made from natural materials that have used the engineer's knowledge of the characteristics of natural materials.
4.2 Identify examples of engineering designs that attempt to duplicate structure of plants.
4.3 Discuss the design of human and animal bones and their resistance to torsion.
4.4 List examples of functional design in animals, such as birds and reptiles
4.5 Identify the honeycomb structure in nature and engineering designs
5. REVIEWING THE ENGINEERING DESIGN PHASES
5.1 Define and list steps in the engineering design process.
5.2 Define what an "optimum design" is and why one rarely exists.
5.3 List the three phases used in most engineering designs.
5.4 Describe the objectives of the feasibility study.
5.5 Explain the use of the evaluation table in selecting the best alternative to develop in detail during the preliminary design phase.
6. USING THE ENGINEERING DESIGN PROCESS IN A GROUP PROJECT
6.1 Participate in a brainstroming session dealing with a specific problem.
6.2 Discuss the sources of information available to an engineer for problem solving.
6.3 Discuss the use of sketches, detail and assembly drawings in the design process.
6.4 Discuss the use of anthropometric tables.
6.5 Select appropriate materials and processes for design project.
6.6 Utilize tools, machines, and equipment safely.
6.7 List the objectives of an engineering test and safety factors.
6.8 Consider alternate design solutions to problem.

7. COMMUNICATING THROUGH PROPOSALS, GRAPHICS, COMPUTERS, AND REPORTS
    7.1 Write letters, proposals, and technical reports.
    7.2 Solve design problems with engineering graphics, descriptive geometry, and mathematical calculations to aid in the solution of the problem.
    7.3 Present solutions using computer-aided design and drafting.
    7.4 Program computer-aided machines and numerical controls.
    7.5 Communicate with resource persons including engineers, technologists, and library personnel.

8. BRIEFING OTHERS ON THE RESULTS OF ENGINEERING
    8.1 Present an oral report on problem-solving activities.
    8.2 Pre-register for competitive events.
    8.3 Prepare a written technical report on problem-solving activities.
    8.4 Construct a display of activities to use in a public location.

TECHNOLOGY EDUCATION
INSTRUCTIONAL
TASK/COMPETENCIES
for
INTRODUCTION TO ENGINEERING

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INTRODUCTION

The "Introduction to Engineering Curriculum Research Project" has been developed over a three-year period of time July 1985 - June 1987 and directed by the Technology Education Staff, Virginia Department of Education. Many competent and enthusiastic people have been involved in the developmental process of the program. We are grateful for their time, support, and expertise. The consultants have consisted of practicing engineers, school of engineering faculty, community college personnel, supervisors, teacher educators, and technology education teachers.

The curriculum was conceived as a result of numerous reports and dialogue on the need for programs that challenges students to solve problems; provide career guidance in engineering and high technology; and learn the applications of mathematics and scientific principles. This program has been developed as a result to upgrade the curriculum that will challenge potential engineers, technicians and technologists.

Although the program is entitled "Introduction to Engineering" the curriculum is designed to provide teaching and learning experiences in high technical areas in the broadest sense. The Accreditation Board of Engineering and Technology defines engineering as:

> "the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, and with concern for the environment and society the materials and forces of nature for the benefit of mankind."

It has been in this context that the Introduction to Engineering Curriculum has been developed. We were advised by our knowledgeable consultants to develop a curriculum that relates practical applications of "common threads of engineering". The competency tasks have therefore reflected this concept and a broad approach has been taken in developing the program.

There have been benefits in the curriculum development process that have been beneficial other than the end product of a curriculum guide. The involvement of people in the process of curriculum development has been a professional growth opportunity for many people. Inservice for teachers to learn new knowledge, methods, and techniques have been afforded. A public and profesional partnership has been accomplished that will not only be beneficial to the program, but to the total educational endeavors in the future as well.

The most important endeavor that has been made in the whole process is that a number of students' educational needs will be met. It is the youth that we teach and help grow that benefits the most. If we have not accomplished this goal then the process has failed. It is my belief that we succeeded, however.

by Dr. Lynn P. Barrier, Project Director

INT:1

ACKNOWLEDGMENTS

The development and completion of this guide required a vast expendiure of time, effort, and teamwork among the project staff and participants. The teachers who served as researchers and writing team members for the guide are most deserving of recognition for their dedication, time, and expertise:

Bill Blough, Technology Education Teacher, Buffalo Gap High School, Augusta County School Division
Rodney Fulton, Technology Education Teacher, Patrick Henry High School, Roanoke City School Division
Michael Stephens, Technology Education Teacher, Fairfax High School, Fairfax County School Division

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Charles Abdel-Alim, Technology Education Teacher, John Marshall High School, Richmond School Division
David M. Alkazin, Technology Education Teacher, Chantilly High School, Fairfax County School Division
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Thomas Turner, Technology Education Teacher, Martinsville High School, Martinsville School Division
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George Devens, Professor, School of Engineering, Virginia Tech University
Rayford Harris, Professor, Technology Education, Virginia Tech University
James Jacobs, Professor, Technology Education, Norfolk State University
Donald Jameson, Professor, School of Engineering, Virginia Military Institute
Pamela Kurstedt, Administrator, School of Engineering, Virginia Tech University
Leo Padis, Administrator, School of Engineering, Virginia Tech University
Charles Pinder, Professor, Technology Education, Virginia Tech University

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Dicky Morgan, Instructor, Wytheville Community College
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Kenneth Wilson, Supervisor, Fairfax County School Division

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PART 1

PROGRAMS AND COURSES

The course description, content outline, and suggested task sequence contained in this section were developed using the validated task analysis presented in Part 2 of this guide. The program and courses have been approved by the Virginia Department of Education.

The course outline is used by the teacher as a guide to assist in planning instructional procedures and content. Part 2 of this guide contains technology learning activities (TLAs) for each of the task/competencies. These are provided for the teacher to develop appropriate lesson plans.

PROGRAM TITLE: INTRODUCTION TO ENGINEERING

DESCRIPTION:

Introduction to Engineering is a program designed to prepare students more effectively for engineering and related careers. The program integrates the high-tech applications of mathematics and science concepts into pre-engineering activities. The challenges of a career as an engineer, technologist, or technician are explored.

Instruction in **Introduction to Engineering** enables students to experience competencies relevant to engineering principles such as problem solving, materials processing, materials science, and the enterprise system resulting in occupational development useful to the future engineer, technician, technologist, and related career fields.

Program completers are prepared with competencies that will assist them in the future. The program will prepare students to enter employment in technically related fields or articulate for advanced preparation in community college or university programs.

SUGGESTED GRADE LEVEL: 11 - 12

APPROVED COURSE	VA COURSE CODE
CHALLENGES IN ENGINEERING	8490
ENGINEERING PROJECTS	8491

SUGGESTIONS FOR IMPLEMENTING THIS PROGRAM:

This program is designed to challenge the college-bound student. Usually these students have completed algebra, geometry, and may be taking trigonometry and physics along with one of these courses. A basic technical drawing course is suggested for other students prior to these courses.

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CHALLENGES OF ENGINEERING

Suggested Task/Competency Sequence (8490)

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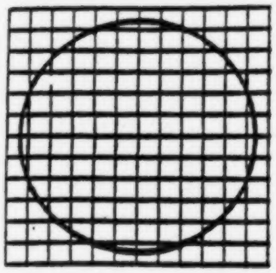
1. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD
    - 1.1 Discuss the effects of the explosion in scientific knowledge on the development of technology.
    - 1.2 Explain the pressing need for more engineers and technicians in the future.
    - 1.3 Identify the members of the technological team and justify its existence.
    - 1.4 Participate in group work and personnel system to manage class and laboratory activities.
2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS
    - 2.1 Summarize the professional characteristics of engineers.
    - 2.2 Outline the principal fields for specialization in engineering.
    - 2.3 Investigate the procedures for becoming a registered engineer in Virginia.
    - 2.4 Describe education needed for specialty fields in engineering and technology.
    - 2.5 Describe the opportunities gained through the study of engineering and technology.
    - 2.6 Establish a professional attitude toward classroom and laboratory activities.
3. APPLYING ENGINEERING GRAPHICS, DESCRIPTIVE GEOMETRY, AND MEASUREMENT
    - 3.1 Distinguish between various measurement systems and their basic units.
    - 3.2 Write a mathematical equation that is constant in units of measurement.
    - 3.3 Interpret drawings using various systems of measurement.
    - 3.4 Use the precision measuring tools and instruments to lay out, measure, and inspect parts or products.
    - 3.5 Measure quantities of materials and conduct tests accurately using SI units and U.S. customary Units.
    - 3.6 Use engineering design graphics and descriptive geometry in the solution of design problems.
    - 3.7 Sketch objects using multi-view and pictorial principles.
    - 3.8 Prepare drawings using basic technical drawing instruments for orthographic projections and isometric projections.
    - 3.9 Use graphs, empirical equations, mechanisms (kinematic representations), graphical mathematics, and nomography in the solution.
    - 3.10 Use graphical vector analysis in the design process.
    - 3.11 Build models that illustrate principle classes of physical models of new engineering creations from graphic solutions.
    - 3.12 Use computer aided design software (CAD) to prepare drawings.
    - 3.13 Use computer aided manufacturing software (CAM) to simulate a manufacturing problem.
4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY
    - 4.1 Recall the history of engineering from the beginning of civilization to the present day.
    - 4.2 Research an engineering achievement to prepare a model or display and a written report.
    - 4.3 Deliver a short oral briefing which explains a technical device or engineering achievement.
5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING
    - 5.1 Apply steps in the problem solving method or process (individual activity).
    - 5.2 Function as an engineer or technologist in problem solving activities.
    - 5.3 Apply mathematical formulas to problems and activities.
    - 5.4 Perform the keyboard functions on a scientific, hand-held calculator.
    - 5.5 Input computers and application programs when appropriate for problem solving activities.



CHALLENGES IN ENGINEERING

This course provides for orientation to the careers and challenges of engineering. Students are actively involved with high tech devices, engineering graphics and math/scientific principles through problem solving experiences. Activities are provided in descriptive geometry, materials science and technical systems. Students communicate information through seminars, technical reports and sharing ideas.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply Technology & Engineering to Life & Work	8490	11 or 12	1 maximum 1 period per day 36 weeks	None

SELECTED COURSE GOALS

Experiences and activities of this TECHNOLOGY EDUCATION course will enable the student to:

1.1 discuss engineering careers, history, practices and concepts.
1.2 apply mathematical and scientific principles to technical problems.
1.3 assess abilities and interests as they relate to engineering and technician level careers.
1.4 communicate through oral, written or graphic means the results of solutions to problems.
1.5 select materials and processes appropriate to need.

2.1 calculate mathematical solutions with calculator.
2.2 use tools and machines necessary for processing materials or products.
2.3 use a computer to analyze data or to interface with practical application.
2.4 solve problems with mechanical and electrical systems.

3.1 display a positive attitude toward the value of engineering practices by citing their contributions to improving our world.
3.2 recognize the value of problem solving, research and development, and technical communications.
3.3 give examples of the value of mathematics and science to practical solutions.

CHALLENGES IN ENGINEERING

COURSE OUTLINE FOR TEACHING FIRST COURSE

CONTENT/CONCEPTS MATCH THOSE ON TASK/COMPETENCY LIST

I. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD (1 WEEK)

A. Provide course overview and description.
B. Relate course to student needs, industry, and "the REAL WORLD".
C. Distribute objectives or task/competency list.
D. Administer details for school and class.

II. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS (1 WEEK)

A. Present slide/tape introducing careers and fields.
B. CLASS ACTIVITY:
   1. Brainstorm to produce a list of questions that the students would like to ask an engineer/technician.
   2. Follow-up with visit by an engineer or technician, or by assigning students to make a telephone intervieew.
C. Teacher forms advisory committees in school and in community.

III. APPLYING ENGINEERING GRAPHICS, DESCRIPTIVE GEOMETRY & MEASUREMENT (12 WEEKS)

IV. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY (1 WEEK)

A. Conduct seminar on significant engineering achievements.
B. CLASS ACTIVITY:
   1. Students select one achievement and do research, produce a display or model, write an outline and give an oral report.

V. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING (5 WEEKS)

A. LABORATORY ACTIVITY:
   1. Bridge building and testing using balsa wood.
   2. Work opportunities in Engineering (stress civil engineering).
   3. Requirements, standards, codes.
   4. Fundamentals of Engineering as they apply to bridge building.
   5. Engineering Design process in bridge design.
   6. Rough sketch of individual design.
   7. Scale working drawings.
   8. Bill of material.
   9. Students build bridge (include safe use of required tools/equipment.) 2 weeks.
   10. Use films or slides about bridges.
   11. Test bridges or make test part of Unit 6.
   12. Use calculator to compute strength, etc.

6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS
    - 6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.
    - 6.2 Use tools, laboratory apparatus and equipment to safely determine the properties of materials.
    - 6.3 Conduct laboratory tests and report results in a written test report.
    - 6.4 List causes of failure in materials and give procedures used to prevent such failures.
    - 6.5 Explain the concept of supply and demand as it relates to materials in short supply.
    - 6.6 Experiment with processes used with metal, woods, polymer, ceramic, and composite materials and adhesives.
7. WORKING WITH DIFFERENT MATERIALS TO SOLVE PROBLEMS
    - 7.1 Function as a member of a team in problem-solving activities.
    - 7.2 Redesign and test a technical device in small groups.
    - 7.3 Use mathematical symbols to express a relationship between two or more variables.
8. COMMUNICATING TECHNICAL INFORMATION
    - 8.1 Examine engineering data and discuss the need for communication.
    - 8.2 Write a technical report (or proposal) for an engineering project.
    - 8.3 Use a computer for word processing technical information.
9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM
    - 9.1 Select a problem or project for improvement.
    - 9.2 List essential steps in the design process.
    - 9.3 Use the steps in the design process to improve a product.
10. RESEARCHING TECHNICAL LIBRARY AND PATENT/INVENTION INFORMATION
    - 10.1 Identify informational references found in a technical library.
    - 10.2 Locate reference books, dictionaries, and periodicals used by engineers.
    - 10.3 Discuss the six legal categories of patents.
    - 10.4 Explain how patents are obtained.
    - 10.5 Describe how patents protect the inventor.
11. COMPUTING DATA FOR SOLVING PROBLEMS
    - 11.1 Perform the keyboard functions on a scientific, hand-held calculator. (See task #5.4 for resource form.)
    - 11.2 Use computers and application programs when appropriate for problem-solving activities (should add more comoputer science here). (See task 3.12 for resource form.)
    - 11.3 Apply mathematical formulas to problems and activities. (See task 5.3 for resource form.)
    - 11.4 Use mathematical symbols to express a relationship between two or more variables. (See task 7.3 resource form.)
12. INTRODUCING THE TEAM CONCEPT AND THE ENGINEERING DESIGN PHASES
    - 12.1 Recall the members of the technological team and the steps in the problem-solving process.
    - 12.2 List the reasons and steps for a feasibility study.
    - 12.3 List the essential steps in the preliminary design phase.
    - 12.4 List the essential steps in the detailed design phase.
    - 12.5 Present overview of the group method to relate the importance of teamwork for problem solving.
    - 12.6 Brainstorm and select possible problem-solving activities for feasibility study.
13. BRIEFING OTHERS ON RESULTS OF ENGINEERING
    - 13.1 Present an oral report on problem-solving activities.
    - 13.2 Pre-register for competitive events.
    - 13.3 Prepare a written technical report on problem-solving activities.
    - 13.4 Construct a display of activities to use in public location.

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VI. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS (4 WEEKS)

A. Include additional required lab safety qualifications.
B. LABORATORY ACTIVITY:
  1. Test and modify hardness of metal.
  2. Use other test equipment to evaluate materials.
  3. Invite speakers or tour local industry.

VII. WORKING WITH DIFFERENT MATERIALS TO SOLVE PROBLEMS (4 WEEKS)

A. (Second bridge building and testing activity, or assign other problem such as glider, mousetrap car, circle cutter.)
B. (Same specs but different materials - small group).
C. Lecture on problem-solving process (includes remaining lab safety qualifications).
D. Maintain log of activities or tasks performed.
E. Use calculator to compute trig and other math formulas.

VIII. COMMUNICATING TECHNICAL INFORMATION (1 WEEK

A. Write technical report on second bridge building and analyze test results.

IX. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM (3 WEEKS)

A. Students try to improve the design of an object
  1. One project (several teams try same product).
  2. Multiple projects (teams assigned to different products).
  3. Individual projects (contemporary or future approach).
B. Students participate in project selection.
C. Determine objectives and parameters for project.
D. Learn the steps in design process.
E. Identify information sources.
F. Use steps to improve product.
G. Make model of design improvements/solutions.

X. RESEARCHING TECHNICAL LIBRARY AND PATENT/INVENTION INFORMATION (1 WEEK)

A. Field trip to museum, technical library, or industry.
B. Use school librarian as resource person.
C. Write to museums and research centers.

XI. COMPUTING DATA FOR SOLVING PROBLEMS (1 WEEK)

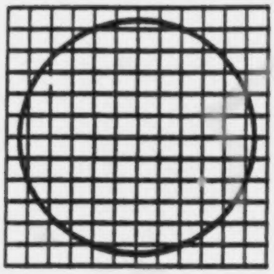
A. Introduction to calculators/computers.
B. Examples of using computational tools in engineering problem solving.
C. Computer Aided Design.
D. Computer simulations.

XII. INTRODUCING THE TEAM CONCEPT AND THE ENGINEERING DESIGN PHASES (IN SECOND COURSE) (1 WEEK)

A. Introduction to group/class activity that could lead into second course.
B. Teach about the engineering design phases.
C. Identify problems for next course.

XIII. BRIEFING OTHERS ON RESULTS OF ENGINEERING (1 WEEK)

A. OPTIONS:
   1. Seminar for outside observers.
   2. Display for school, class, or community.
   3. Register for AIASA Technology Contests.
      a. Bridge Building
      b. Dream House
      c. Technical Writing
   4. Invite engineers to observe seminar by students.



ENGINEERING PROJECTS

This course emphasizes the applications and the design process of engineering. Students form engineering teams and select a group design project. Each team uses communications, graphics, mathematics, and community personnel to solve problems. Appropriate information is learned by each team in order to complete a project. Projects may be models, systems or products that creatively solve an engineering problem.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply Technology & Engineering to Life & Work	8491	12	1 maximum 1 period per day 36 weeks	Recommended as a follow-up to Challenges in Engineering

SELECTED COURSE GOALS

Experiences and activities of this TECHNOLOGY EDUCATION course will enable the student to:

1.1 work as an engineering team to select a problem related to engineering.
1.2 follow the engineering design process to design and build a solution, project, or model.
1.3 apply mathematics and science to solution of problem.

2.1 select and use resources, tools, machines, and materials in completion of a design solution.
2.2 use computers to design, control, or simulate engineering solutions.
2.3 experiment, test, and build a product, system, invention, or prototype.

3.1 work cooperatively in a group, both as a leader/ manager, or as a team member.
3.2 discuss contributions and value of mathematics, science, and technology to the work of an engineer.
3.3 cite examples of ways by which engineering has improved society and the lives of people.
3.4 share and report information during seminars.

ENGINEERING PROJECTS

Suggested Task/Competency Sequence (8491)

1.RELATING OBJECTIVES OF COURSE TO STUDENTS AND SOCIETY

1.1 List courses that help an engineer work with, for, and communicate with people.
1.2 List ways an engineer can prevent his/her knowledge and skills from becoming obsolete.
1.3 Discuss the impact of engineering on society and the environment.
1.4 Identify appropriate community activities for engineers.

2. REVIEWING THE TECHNOLOGICAL TEAM AND RELATED CAREERS

2.1 List the members of the technological team and describe their responsibilities.
2.2 Describe the formal educational background of an engineering technologist.
2.3 Write the definition of an engineer.
2.4 Discuss ways that all engineers are managers.
2.5 List the levels of management wherein an engineer might work.

3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY

3.1 Identify and describe engineering problems and their solutions.
3.2 Describe the application of mathematics in the solution of engineering problems.
3.3 Describe the application of scientific principles in the solution of engineering problems.
3.4 Describe the application of technology in the solution of engineering problems.
3.5 Utilize tools, machines, and equipment safely.
3.6 Prepare a model of the solution of an engineering problem.
3.7 Use engineering graphics to describe the solution of an engineering problem.
3.8 Describe the social, cultural, and environmental impact of an engineering
3.9 Present an oral report on the solution of an engineering problem.

4. OBSERVING DESIGNS IN NATURE

4.1 Describe examples of products made from natural materials that have used the engineer's knowledge of the characteristics of natural materials.
4.2 Identify examples of engineering designs that attempt to duplicate structure of plants.
4.3 Discuss the design of human and animal bones and their resistance to torsion.
4.4 List examples of functional design in animals, such as birds and reptiles
4.5 Identify the honeycomb structure in nature and engineering designs

5. REVIEWING THE ENGINEERING DESIGN PHASES

5.1 Define and list steps in the engineering design process.
5.2 Define what an "optimum design" is and why one rarely exists.
5.3 List the three phases used in most engineering designs.
5.4 Describe the objectives of the feasibility study.
5.5 Explain the use of the evaluation table in selecting the best alternative to develop in detail during the preliminary design phase.

6. USING THE ENGINEERING DESIGN PROCESS IN A GROUP PROJECT

6.1 Participate in a brainstroming session dealing with a specific problem.
6.2 Discuss the sources of information available to an engineer for problem solving.
6.3 Discuss the use of sketches, detail and assembly drawings in the design process.
6.4 Discuss the use of anthropometric tables.
6.5 Select appropriate materials and processes for design project.
6.6 Utilize tools, machines, and equipment safely.
6.7 List the objectives of an engineering test and safety factors.
6.8 Consider alternate design solutions to problem.

7. COMMUNICATING THROUGH PROPOSALS, GRAPHICS, COMPUTERS, AND REPORTS
    7.1 Write letters, proposals, and technical reports.
    7.2 Solve design problems with engineering graphics, descriptive geometry, and mathematical calculations to aid in the solution of the problem.
    7.3 Present solutions using computer-aided design and drafting.
    7.4 Program computer-aided machines and numerical controls.
    7.5 Communicate with resource persons including engineers, technologists, and library personnel.
8. BRIEFING OTHERS ON THE RESULTS OF ENGINEERING
    8.1 Present an oral report on problem-solving activities.
    8.2 Pre-register for competitive events.
    8.3 Prepare a written technical report on problem-solving activities.
    8.4 Construct a display of activities to use in a public location.

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ENGINEERING PROJECTS

COURSE OUTLINE for TEACHING SECOND COURSE

I. Relating Objectives of Course to Students and Society (2 days)

A. Course overview and description.
B. Accomplish administrative details for school and course.
C. Relate course to student needs, interests, and the needs of industry for technicians, technologists, and engineers.
D. Help students realize the importance of engineering in our world.
E. Emphasize need for good study habits and study of other subjects related to technology.
F. Discuss current events related to engineering.

II. Reviewing the Technological Team and Related Careers (4 days)

A. Review and have students discuss career aspects of first course.
B. Show one part of "Introduction to Engineering, Technology and Its Careers" slide/tape program and discuss.
C. Show another part of the Careers slide/tape progam and discuss.
D. Help students to define engineer and learn career information. subjects related to technology.
F. Involve Guidance Personnel for career and educational information.

III. Preparing a Formal Seminar on an Engineering Case Study (8 weeks)

A. Identify an Engineering Project such as the Brooklyn Bridge, Panama Canal, or Hoover Dam.
  1. Teacher should be sure this assigned topic has lots of reference materials for students to use in study.
  2. Follow and study a project underway near school such as sewer line, water treatment plant, highway bridge, road, or building.
B. Requirements of the Unit method for this investigation.
  1. Unit study of problems confronted in a major engineering achievement and how these problems were solved.
  2. Individual projects to be presented to class in a formal seminar, called a "briefing."
  3. Required research on an assigned area of engineering project.
    a. Identify a design or implementation problem.
    b. Discover how the problem was solved.
    c. Identify mathematics, science and technology principles involved.
    d. Determine human and environmental factors involved

Unit III continued for Second Course

4. Required Presentation or Formal Briefing for 15 minutes.
    a. Prepare briefing report on the identified problem and its solution.
    b. Use appropriate drawings, charts, and graphs
    c. Construct a model depicting the problem and solution
    d. Explain the applications of mathematics, science and technology
    e. Describe the social, cultural, and environmental impacts

C. Hold a Preliminary Seminar
    1. Students report on research findings they have found since starting this assignment.
    2. Students discuss ways to best present a formal briefing (specific graphs, models, demonstrations, etc.).
    3. Individual students and teacher reach agreement upon items to be prepared (could be a contract between student and teacher).

D. Teach students laboratory safety and qualify them to use laboratory machinery.

E. Students work on individual drawings and projects/models and presentations.
    1. Announce and hold bi-weekly seminars for the reporting of progress and discussion of problems encountered.
    2. Assist students with individual work as they need help.

F. Teach Communications Skills (refer to book Disciplined Creativity)
    1. Effective Communications are important.
    2. Blocks to effective communication.
        a. The decision to communicate.
        b. Communication goals.
        c. Steps in preparing effective oral communications. (graphic and AV aids)
        d. Common errors made in oral communications.

G. The Formal Seminar/Briefing
    1. Each student presents formal briefing to class (3 or 4 reports per day).
    2. A seminar is conducted for invited guests (principal, superintendent, supervisors, engineers, etc.)
        a. Three selected students will make presentations.
        b. All other students will set up displays of their work at the seminar site.

IV. Observing Designs in Nature (2 days)

A. Products and characteristics of natural materials.
B. Structure of plants.
C. Human and animal bones.
D. Birds and reptiles.
E. Relate product design to nature and engineering.

Second Course Continued

V. Reviewing Engineering Design Phases (6 weeks)

A. List steps in Design Process
B. Brainstorm to identify problems
C. Feasibility Study Phase
   1. Economics
   2. Production and Marketing
D. Preliminary Design Phase
E. Detail Design Phase
   1. Planning Engineering Projects
   2. Design Philosophy
      a. Safety
      b. Service
F. Review and teach major steps in Chapter 11.
   1. Invite guest speaker to talk about processes used.
   2. Obtain audio visual materials to use in teaching.
G. Assign readings in Chapter 11.

VI. Using the Engineering Design Process in a Group Project (18 weeks)

(Plan to have group project completed by end of school year.)

A. Introduce Engineering Project as a group/class experience.
B. Explain method to be used for this experience in engineering.
   1. Group project approach.
      a. Students form an Engineering Team to select and solve an engineering problem.
      b. At end of activity students will exhibit project, display information and report on activities completed.
C. Problem selection.
   1. Identify possible problems.
      a. Brainstorm in class.
         Example problems: elevator
                           wind tunnel
                           mass transit
                           nuclear safety
      b. Request suggested problems from faculty, other classes, engineers, etc.
      c. List all suggestions and then have students narrow it down.
      d. Select problems related to science or math.
   2. Students select three problems for careful consideration.
   3. Feasibility Study. (Refer to book Careers in Engineering and Technology.)
      a. A student team is assigned to study each of the three problems under consideration.
      b. Each team will present findings as to the feasibility of a solution to their assigned problem.
      c. Teams consider tool needs, resources, and materials available.
   4. Students make final selection of a single problem for solution by class as an engineering team.

Unit VI continued For Second Course

D. The Design Process.
In clearly identified steps, conduct team meetings to plan the activities in each step and to report on progress. Form a Personnel Management Team to carry out steps.
(Follow steps in Careers in Engineering and Technology book.)
1. Step 1-Identification of the problem. (prepare a problem statement)
2. Step 2-Collection of information. (assign individuals to do research.
3. Step 3-Generation of ideas.
    a. Invention/Innovations
    b. Questions and Checklists
    c. List Properties and Alternatives
    d. Brainstorming
    e. Synectics or Inanimate Problem Solving
4. Step 4-Preparation of a model or graphic simulation. (divide class into subgroups to work)
    a. Hard Models
    b. Charts and Graphs
    c. Diagrams and Simulations by Computer
5. Step 5-Testing. (Be sure the solution will work.)
    a. Quality Assurance
    b. Performance Tests
    c. Safety Tests
    d. Envess to a Team Project

VII. Communicating Through Proposals, Graphics, Computers, and Reports (2 weeks)

(Use Disciplined Creativity book)

A. Review major points from First Course.
B. Students working as a team produce an engineering report on the problem and its solution.

VIII. Briefing Others on the Results of Engineering (2 days)

A. Culminating Activity. (Invite guests to view a display of the project results and to receive a copy of the engineering report.)
B. Display model and report for public viewing in appropriate location.

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PART 2

TASK INVENTORY

One of the major chaeracteristics of competency-based education (CBE) is that the course content is based upon actual jobs or tasks performed by persons living and working in the technological world. In Virginia, the Department of Education has established standards for competency-based education. According to these standards, competencies must be "role-relevant" and based upon "appropriate research." This standard states:

> Role-relevant competencies that include standards are identified and stated.
>
> The competencies with standards will be identified through V-TECS, IDECC, and other appropriate research. Advisory committees should be used to review competencies and standards. Competencies in the affective domain will be included. Role-relevant competencies for occupational preparation programs are those that specifically relate to the occupation for which the student is being prepared as well as to the personal needs of the student. Role-relevant competencies are related also to orientation, exploration, or technology education experiences which have been identified for students.

Therefore "role-relevant" jobs or tasks, called competencies in CBE, must be identified and validated before instructional materials are developed and subsequent instruction can take place.

The task list contained in this instructional guide was based on the following:

1. Interviews with engineers and technologists at NASA and in private sectors.
2. The review and selection of appropriate resource materials.
3. Input from engineering faculty and technology teachers.
4. Input from mathematics, science, and technology education supervisors.

Based upon the information collected and reviewed from the available sources, a task inventory was prepared.

The next major step involved in the development of the task inventory was validation of the task list. Validation is essential if the information collected is to be useful in operating CBE courses and programs. The validation process involved the following:

1. Review by writing-team members to determine completeness of the inventory.
2. Review and validation by state consultants to ensure the role-relevance and completeness of the inventory.
3. Pilot testing by local technoloy education teachers to determine the validity of the inventory.
4. Final review and editing by writing-team members, project directors, and state staff.

The task list included in this publication was based on current available resources and validated by teachers, advisory committee members, and persons employed in engineering and technology. The tasks are offered as guidance to teachers. Many tasks build upon others taught earlier. The methods of instruction and technology learning activities are suggested but can be varied to meet sutdent needs.

The program Introduction to Engineering consists of two courses which are each one year in length. Minimum competencies for each course are sequenced and a course outline is provided in Part 1 of this package. Objectives, activities, and resources for teaching each task/competency are provided in Part 2.

CONTENT/CONCEPT AREAS

FOR

CHALLENGES IN ENGINEERING

1. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD.
2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS.
3. APPLYING ENGINEERING GRAPHICS, DEXCRIPTIVE GEOMETRY, AND MEASUREMENT.
4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY.
5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING.
6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS.
7. WORKING WITH DIFFERENT PROCESSES TO SOLVE PROBLEMS.
8. COMMUNICATING TECNICAL INFORMATION.
9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM.
10. RESEARCHING TECHNICAL LIBRARY AND PATENT INVENTION INFORMATION.
11. COMPUTING DATA FOR SOLVING PROBLEMS.
12. INTRODUCING THE TEAM CONCEPT AND THE ENGINEERING DESIGN PHASES.
13. BRIEFING OTHERS ON RESULTS OF ENGINEERING.

Cont:1
LB2

CONTENT/CONCEPT AREA

1. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD.

TASKS/COMPETENCIES

1.1 Discuss the effects of the explosion in scientific knowledge on the development of technology.

1.2 Explain the pressing need for more engineers and technicians in the future.

1.3 Identify the members of the technological team and justify its existence.

1.4 Participate in group work and personnel system to manage class and laboratory activities.

CONTENT/CONCEPT	COURSE
1. Relating Objectives of Course to Technical World	CHALLENGES IN ENGINEERING

TASK/COMPETENCY

1.1 Discuss the effects of the explosion in scientific knowledge on the development of technology.

1.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.1 Given information about course and activities, discuss the effects of the explosion in scientific knowledge on the development of technology. Effects must include the need for math, science, and computer principles.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.1.1 List course activities by reading handouts about course and activities discussed by teacher.

E.1.1.2 Explain some changes in the world that resulted from scientific knowledge presented in teacher's lecture.

E.1.1.3 Identify changes in technology by bringing in photos and newspaper magazine articles.

E.1.1.4 Recall challenging areas of engineering after viewing a film, such as the Challenges of Manufacturing

CONTENT/CONCEPT

1. Relating Objectives of Course to Technical World

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

1.2 Explain the pressing need for more engineers and technicians in the future.

1.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P 1.2 Given information and readings about the future, explain the pressing need for more engineers and technicians in the future. Explanation must include mention of energy, micro electronics, and space travel.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E 1.2.1 Discuss the recent changes in technology mentioned in textbook readings.

E 1.2.2 Cite reasons why women have not been involved in engineering and other technical careers.

E 1.2.3 Explain the need for more qualified industrial engineers and technologists by touring local industry or hearing speaker.

CONTENT/CONCEPT	COURSE
1. Relating Objectives of Course to Technical World	CHALLENGES IN ENGINEERING

TASK/COMPETENCY

1.3 Identify the members of the technological team and justify its existence.

1.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P 1.3 Given textbook readings, identify the members of the technological team and justify its existence by describing team members unique roles and characteristics.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E 1.3.1 Discuss the work of a craftsperson after reading textbook and viewing film.

E 1.3.2 Report on the work of a technician after reading textbook and reviewing information from community college.

E 1.3.3 Contrast the work of a technologist with that of an engineer after reading textbook and career literature.

E 1.3.4 Describe how scientists are educated and the work they do.

CONTENT/CONCEPT

1. Relating Objectives of Course
   to Technical World

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

1.4 Participate in group work and personnel system to manage class and laboratory activities.

1.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.4 Given information about the course and activities, participate in group work and personnel system to manage activities as a leader and follower.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.4.1 Identify the leadership positions needed for technology student activities by learning about other organizations.

E.1.4.2 Define and list duties of president, secretary, treasurer, and reporter used to help manage organizations and groups.

E.1.4.3 Participate as officer/leader of group by forming a demoncratic organization to manage class.

E.1.4.4 Prepare an organizational chart showing leaders and technological team members needed within class.

COURSE: CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

1. RELATING OBJECTIVES OF COURSE TO TECHNICAL WORLD

EQUIPMENT AND MATERIALS

RESOURCES

Handout listing course information and objectives
Posterboard to illustrate class leaders and technological team
Career literature about technicians trained by community colleges
Career information about technologists and engineers

Textbooks:
Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA :2180.
Beakley, George C., Careers in engineering and Technology, Third Edition, Macmillan Publishing Co., NY 1984.

AUDIO-VISUAL MATERIALS

Slide/Tape: Engineering: An Introduction to the Field and Its Careers
Video Tape: AIASA: A Technical World
Movie: The Challenge of Manufacturing by Society of Manufacturing Engineers. May be borrowed from Virginia Technology Education Service

CE1:1
PRE-Engr5 or PE5

CONTENT/CONCEPT AREA

2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS.

TASKS/COMPETENCIES

2.1 Summarize the professional characteristics of engineers.

2.2 Outline the principal fields for specialization in engineering.

2.3 Investigate the procedures for becoming a registered engineer in Virginia.

2.4 Describe education needed for specialty fields in engineering and technology.

2.5 Describe the opportunities gained through the study of engineering and technology.

2.6 Establish a professional attitude toward classroom and laboratory activities.

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.1 Summarize the professional characteristics of engineers.

2.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.1 Given an overview of the engineering field and related careers, identify the engineering terms with their related fields and definitions by matching 20 items matching test.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.1.1 Discuss the words "engineering profession" and "engineer" in the proper context by defining profession, professional engineer, technician, registered engineer, and engineering profession.

E.2.1.2 Explain the use of the word "professional" when describing an engineer.

E.2.1.3 Explain the use of the word "certified" engineering technologist, or technician, as done by societies such as SME, NSPE (National Society of Professional Engineers), through NICET (National Institute for Certification in Engineering Technologies).

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.2 Outline the principal fields for specialization in engineering.

2.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.2 After interviewing an engineer in a specific field, outline distinguishing characteristics of 2 types of engineers and 2 types of related careers.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.2.1 List the types of work for engineers in other related career fields.

E.2.2.2 Distinguish between a licensed architect and an architectural engineer by interviewing either of the two.

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.3 Investigate the procedures for becoming a registered engineer in Virginia.

2.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.3 Given a list of professional engineering societies, write a letter to a society requesting the requirements of becoming a registered engineer in Virginia.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.3.1 Discuss the possible use of the word "engineer" in the name of a new construction firm by making a line organization chart showing the construction firm's management personnel.

E.2.3.2 Explain how engineering societies use "certification" for engineering technicians and technologists.

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.4 Describe education needed for specialty fields in engineering and technology.

2.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.4 Given an overview of standards for licensing in specialty fields of engineering, describe the education needed in 2 specialty fields in engineering and technology.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.4.1 Write letters to request information about schools and careers by choosing one out-of-state university, one instate community college, and one local industry/business.

E.2.4.2 List engineering schools and entrance requirements by reviewing catalogs of schools offering engineering programs in Virginia and write the Dean of the School Engineering for entrance requirements.

E.2.4.3 List technology schools and entrance requirements by reviewing catalogs of community colleges offering technology or technician programs and write the admissions office for entrance requirements.

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.5 Describe the opportunities gained through the study of engineering and technology.

2.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.5 Given the related social studies units taught in the high school and the list of societies/professional organizations, describe two career opportunities in engineering and technology.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.5.1 Explain the value of courses in the humanities and social sciences to the professional engineer by relating units of study currently taken or taken in the past.

E.2.5.2 List the name and professional benefits of associations or societies for engineers by reviewing the brochures and catalogs.

CONTENT/CONCEPT

2. Investigating the Engineering Profession and Related Careers

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

2.6 Establish a professional attitude toward classroom and laboratory activities.

2.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.6 Given a mathematical concept problem relating to a typical engineering practice, establish an attitude toward the extensive requirements for time spent in study of a current mathematics course such as geometry, trigonometry, etc.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.6.1 Contrast high school and college study habits and skills by comparing mathematical concepts required for engineers and mathematical concepts required of political science.

E.2.6.2 List ways that practicing engineers keep up-to-date and continue learning by interviewing a practicing engineer.

E.2.6.3 Formulate important questions for potential engineers by answering the statements listed in appendix ?? by Anderson such as "Do I Have An Inquisitive Searching Mind?" "Do I Like to Solve Problems and Puzzels?" "Do I Enjoy Learning?" "Can I Organize My Time?" "Am I Willing To Work Hard?"

E.2.6.4 Organize an advisory committee using engineers and technical personnel from community

E.2.6.5 Ask tecahers from mathematics, science and English to serve as consultants to students in this engineering related class.

COURSE: CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

2. Investigating the Engineering Profession and Related Careers

EQUIPMENT AND MATERIALS

Slide Projector
Tape Recorder
Poster/Chart Board

RESOURCES

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Harbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180.
Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Co., NY, 1984.
Transparencies by Anderson, "Important Questions for Potential Engineers"
University and community college catalogs
Materials in Guidance Counselor's Office
Professional Society of Engineers' literature and brochures
NASA Technician Program information
Engineering Career information from JETS

AUDIO-VISUAL MATERIALS

Slide/tape presentation: Engineering: An Introduction to the Field and Its Careers
Film: Challenge of Manufacturing, SME

CE2:1
PE5

CONTENT/CONCEPT AREA

3. APPLYING ENGINEERING GRAPHICS, DESCRIPTIVE GEOMETRY, AND MEASUREMENT.

TASKS/COMPETENCIES

3.1 Distinguish between various measurement systems and their bases units.

3.2 Write a mathematical equation that is constant in units of measurement.

3.3 Interpret drawings using various systems of measurement.

3.4 Use the precision measuring tools and instruments to lay out, measure, and inspect parts or products.

3.5 Measure quantities of materials and conduct tests accurately using SI Units and U.S. Customary Units.

3.6 Use engineering design graphics and descriptive geometry in the solution of design problems.

3.7 Sketch objects using multi-view and pictorial principles.

3.8 Prepare drawings using basic technical drawing instruments for orthographic projections and isometric projections.

3.9 Use graphs, empirical equations, mechanisms (kenematic representations), graphical mathematics, and nomography in the solution.

3.10 Use graphical vector analysis in the design process.

3.11 Build models that illustrate principle classes of physical models of new engineering creations from graphic solutions.

3.12 Use computer aided design software (CAD) to prepare drawings.

3.13 Use computer aided manufacturing software (CAM) to simulate a manufacturing problem.

CONTENT/CONCEPT	COURSE
3. Applying engineering graphics, descriptive geometry, and measurement.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
3.1 Distinguish between various measurement systems and their bases units.	3.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.1 Given a variety of problems, students will correctly solve them mathematically by the use of different measurement units.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.1.1 Solve problems dealing with length, volume, and mass using The English System.

E.3.1.2 Solve problems dealing with length, volume and mass using The System International.

CONTENT/CONCEPT

COURSE

3. Applying engineering graphics, descriptive geometry, and measurement.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

3.2 Write a mathematical equation that is constant in units of measurement.

3.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.2 Given a variety of mathematical problems, students will convert the data so that one unit is used to correctly solve the problem.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.2.1 Convert various measurement units to the base standard of that unit.

E.3.2.2 Solve problems with constant measurement units.

CONTENT/CONCEPT	COURSE
3. Applying engineering graphics, descriptive geometry, and measurement.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

3.3 Interpret drawings using various systems of measurement.

3.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.3 Given descriptive geometry problems interpret the drawing using U.S. Customary Unit on one drawing and the SI Unit on one drawing and use the conversion table to convert the two to the nearest whole unit.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.3.1 Explain the U.S. Customary/American Engineering Systems of Units by drawing a descriptive geometry problem.

E.3.3.2 Use the SI Units for Measurement by drawing a descriptive geometry problem.

E.3.3.3 Use conversion tables to convert from one unit to another by converting measurements of drawings using SI Units to U.S. Customary Units.

CONTENT/CONCEPT

3. Applying engineering graphics, descriptive geometry, and measurement.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

3.4 Use the precision measuring tools and instruments to lay out, measure, and inspect parts or products.

CODE

3.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.4 Given a problem to manufacture a marketable product, use precision measuring tools and instruments to lay out, measure, and inspect parts of a product to +/- one mm.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.4.1 Design a product to be manufactured by submitting various prototypes for market survey and usefulness.

E.3.4.2 Disassemble an existing product to measure the tolerances by using a micrometer and record the differences in the fitted parts.

E.3.4.3 Fit interchangeable parts together by making three irregular shaped objects that fit internally in each such as 3/circles in 3/rings interchangeable.

CONTENT/CONCEPT	COURSE
3. Applying engineering graphics, descriptive geometry, and measurement.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY CODE

3.5 Measure quantities of materials and conduct tests accurately using SI Units and U.S. Customary Units.

3.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.5 Given a quantity of materials to be shipped, calculate the cost of $1.00 per kilogram and per pound and add shipping cost of the material to the product that costs $2.50 to manufacture and determine to total cost with 50% profit.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.5.1 Express the appropriate prefix and symbol correctly of the following units:
- One million kilograms
- One ten-thousandth of a meter
- One million newtons

E.3.5.2 Write the following numbers using the appropriate SI notation:
- One thousand
- Ten thousand
- Ten million
- One tenth (to two decimal places)

Repeat the above and use appropriate U.S. Customary.

E.3.5.3 Compute the number of new cars loaded on a highway carrier leaving Detroit three times a day for 30 days by calling local car dealer for information on the number of cars loaded on a common carrier.

E.3.5.4 Compute a certain material that costs $10/lbm by expressing the cost in dollars per kilogram.

CONTENT/CONCEPT

3. Applying engineering graphics, descriptive geometry, and units of measurement.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

3.6 Use engineering design graphics and descriptive geometry in the solution of design problems.

CODE

3.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.6 Given descriptive geometry problems, demonstrate a working knowledge of the rules and concepts of descriptive geometry through the successful completion of seven practical engineering problems as intended to suggest the level of competence of work that may be required by the instructor.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.6.1 Identifying planes, objects, and line types with appropriate measurements.

E.3.6.2 Applying proper notations to the solutions of problems.

E.3.6.3 Applying the principles and concepts to the solution of problems.

E.3.6.4 Finding the true length, slope, and bearing of a line.

E.3.6.5 Determining the true size and shape of surfaces.

CONTENT/CONCEPT	COURSE
3. Applying engineering graphics, descriptive geometry, and measurements.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

3.7 Sketch objects using multi-view and pictorial principles.

3.7

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.7 Given a mechanical part, model, or technical drawing problem, sketch an object showing the three orthographic views and the pictorial view of the same object in proportion measured by the eye.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.7.1 Prepare a drawing problem by demonstrating the techniques of sketching straight and curved lines.

E.3.7.2 Prepare a drawing problem by lisiting several applications of freehand sketching.

E.3.7.3 Prepare a drawing problem by demonstrating the techniques of proportioning.

E.3.7.4 Prepare a drawing problem by sketching the three principle orthographic views.

E.3.7.5 Prepare a drawing problem by sketching a pictorial view of single parts or models.

E.3.7.6 Prepare a drawing problem by constructing three dimensional models from orthographic drawings.

CONTENT/CONCEPT

COURSE

3. Applying engineering graphics, descriptive geometry, and measurement.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

3.8 Prepare drawings using basic technical drawing instruments for orthographic projections and isometric projections.

3.8

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.8 Given a drawing problem of a mechanical part or model, interpret orthographic projection and isometric projection using basic technical drawing instruments to draw the three views and isometric view of the same object.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.8.1 Prepare a drawing problem by demonstrating the techniques of drawing straight and curved lines.

E.3.8.2 Prepare a drawing problem by demonstrating the three views of a single object.

E.3.8.3 Prepare a drawing problem by demonstrating the angle of an isometric view of a single object.

E.3.8.4 Prepare a drawing problem by constructing a three dimensional model from an orthographic drawing.

CONTENT/CONCEPT	COURSE
3. Applying engineering graphics, descriptive geometry, and measurement.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
3.10 Use graphical vector analysis in the design process.	

3.10

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.10 Given a problem involving vector analysis, use graphical vector analysis as one means of its solution. Use must include both an accurate manual analysis and an analysis using computer graphics.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.10.1 Use engineering graphics to construct a space diagram and a free body diagram accurately representing a system of forces.

E.3.10.2 Use computer graphics to construct a free body diagram accurately representing a system of forces.

E.3.10.3 Use an accurately constructed free body diagram to estimate unknown quantities in a system of forces.

CONTENT/CONCEPT

COURSE

3. Applying engineering graphics, descriptive geometry, and measurements.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

3.9 Use graphs, empirical equations, mechanisms (kenematic representations), graphical mathematics, and nomography in the solution.

3.9

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.9 Given a design problem, use appropriate means of solving and reporting on the solution of repetitive mathematical computations and observations of physical test data.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.9.1 Describe the methods used prior to the computer age for expeditiously approximating the solution of repetitive mathematical computations (graphical mathematics and nomography).

E.3.9.2 Derive and use empirical equations to expand test data beyond that observable in the lab.

E.3.9.3 Select scales for graphs that will yield the best representation of the data to be communicated.

E.3.9.4 Program a computer to solve repetitive mathematical computations.

E.3.9.5 Use computer graphics to communicate test results.

CONTENT/CONCEPT

3. Applying engineering graphics, descriptive geometry, and measurement.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

3.11 Build models that illustrate principle classes of physical models of new engineering creations from graphic solutions.

CODE

3.11

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.11 Given a design problem for the need of a product, build models that illustrate principle classes of four types of physical models (proof of principle model, scale model, experimental model, prototype model) - Ref. Bailey.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.11.1 Illustrate the "proof of principle model" by designing and constructing a minimally operative model (p. 244, Bailey).

E.3.11.2 Illustrate the "scale model" by designing and constructing a dimensionally enlarged and shrunken model (p. 244, Bailey).

E.3.11.3 Illustrate the "experimental model" by desiging and constructing a functioning model to be tested (p. 244, Bailey).

E.3.11.4 Illustrate the "prototype model" by designing and constructing a full scale working model in a complete form (p. 244, Bailey).

CONTENT/CONCEPT

3. Applying engineering graphics, descriptive geometry, and measurement.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

3.12 Use computer aided design software (CAD) to prepare drawings.

3.12

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3 .2 Given a problem in graphics illustrations, use a computer aided design to prepare drawings of a product.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.12.1 Follow the computer commands to prepare a drawing by following the menu to change functions.

E.3.12.2 Follow the functions by zooming in and out by enlarging and reducing a drawing, pan drawing by moving the drawing across the screen in any direction, locate and draw a circle by placing the point to the circle's center, draw lines, dimension drawings.

CONTENT/CONCEPT

COURSE

3. Applying engineering graphics, descriptive geometry, and measurement.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

3.13 Use computer aided manufacturing software (CAM) to simulate a manufacturing problem.

3.13

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.13 Given a problem to solve using "The Factory" software, simulate a manufacturing problem according to the program of the software functions.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.13.1 Discuss the mathematical concept of rotation. What does it mean to rotate an object 45 degrees, 90 degrees, 135 degrees?

E.3.13.2 Assign individual students to work on computer at different times. Suggest all start on Test A.

E.3.13.3 Using the Factory Product Sheet, students design their own product on paper and then try to produce it with the Factory Program.

E.3.13.4 Investigate other programs, such as Gears, etc.

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

3. Applying engineering graphics, descriptive geometry and measurements.

EQUIPMENT AND MATERIALS

Drafting Board
Drawing pencils
Dividers
Triangles
Calculator
T-Square
Architect scale
Drafting tape

CAD software & hardware
CAM software & hardware
Models/mockups
Mechanical parts
Cardboard
Styrofoam
Poster board

RESOURCES

Projector overlays devised by the instructor of:
- Plane Identification - Page 3 in text
- Normal Objects & Surfaces - Page 7 in text
- Inclined Objects & Surfaces - Page 8 in text
- Oblique Objects & Surfaces - Page 9 in text

Alkazin, D. M., Descriptive Geometry Workbook, Prakken Publications, 1985.

Bailey, R. L., Disciplined Creativity for Engineering, Ann Arbor Science, The Butterworth Group, 1978.

Betts, John E., Physics for Technology.

Earle, James H., "Fundamentals of Spatial Relationships," in Engineering Design Graphics, Addison-Wesley, 1980.

French, Thomas E., et al., "Basic Descriptive Geometry," in Mechanical Drawing, McGraw-Hill, 1980.

Gianchino, J. W. and H. J. Beukema, "Descriptive Geometry and Revolutions," American Technical Society, 1968.

__________. "Practical Descriptive Geometry," in Engineering Technical Drafting, American Technical Society, 1978.

Spencer, Henry Cecil and John Thomas Dygdon, "Descriptive Geometry," - in Basic Technical Drawing, Macmillan, 1974.

Wellman, B. Leighton, "Points and Lines and Plane Surfaces," in Technical Descriptive Geometry, McGraw-Hill, 1957.

AUDIO-VISUAL MATERIALS

CONTENT/CONCEPT AREA

4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY.

TASKS/COMPETENCIES

4.1 Recall the history of engineering from the beginning of civilization to the present day.

4.2 Research an engineering achievement to prepare a model or display and a written report.

4.3 Deliver a short oral briefing which explains a technical device or engineering achievement.

CONTENT/CONCEPT

4. Citing the Contributions of Engineering in History

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

4.1 Recall the history of engineering from the beginning of civilization to the present day.

4.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.1 Given textbook readings and historical films, recall the history of engineering by citing major engineering accomplishments from beginning of civilization to present day.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.1.1 Cite examples of engineering feats by watching movies, slides, and videos. (see list of movies, slides, and videos in appendicies)

E.4.1.2 Draw a time line showing technological advances through the ages by referring to encyclopedia and other library references.

E.4.1.3 Relate early devices to time line by photocoping pictures from magazines and books.

CONTENT/CONCEPT

4. Citing the Contributions of Engineering in History

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

4.2 Research an engineering achievement to prepare a model or display and a written report.

4.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.2 Given a range of time in history, research an engineering achievement to prepare a model or display and written report which describes its contribution.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.2.1 Select an engineering achievement from a range of time in history. Use library resources and textbooks to find information.

4.2.2 Use library references and testbooks to find information.

E.4.2.3 List safety rules appropriate to tools and machines demonstrated by teacher.

E.4.2.4 Sketch model of engineering achievement and specify material needed for model.

E.4.2.5 Select tools and machines for making model with instructor's approval.

E.4.2.6 Outline report about contributions of engineering using library references.

E.4.2.7 Write short report and utilize good communication skills.

CONTENT/CONCEPT

4. Citing the Contributions of Engineering in History

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

4.3 Deliver a short oral briefing which explains a technical device or engineering achievement.

4.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.3 Given a classroom seminar, deliver a short oral briefing which explains a technical device or engineering achievement. The report should cite problems solved and important contributions.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.3.1 Report to class in early seminar on topic selected.

E.4.3.2 Locate library references after librarian explains use of library to class.

E.4.3.3 Work together with other students to prepare model and report.

E.4.3.4 Practice giving oral report to another student or family member.

E.4.3.5 Make poster to illustrate contributions and problems solved by the technical device.

COURSE: CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

4. Citing the Contributions of Engineering in History

EQUIPMENT AND MATERIALS

Basic tools and machines for making models.
Wood, cardboard, and other materials.
Glue and fasteners for assembly of models.

RESOURCES

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Harbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180.

Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Co., NY, 1984.

Library reference books and encyclopedias

World History Chart (Timeline Chart)
Price: $34.95
Order From: International Time Line
2565 Chain Bridge Road
Vienna, VA 22180

(Students may create a timeline across classroom by making cards to hang on string for each invention and date etc.)

AUDIO-VISUAL MATERIALS

Video tape: Out of the Fiery Furnace by BBC
Film: "How to Make a Poster"
Filmstrip: Basic Tools and Safety with Tools

CONTENT/CONCEPT AREA

5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING.

TASKS/COMPETENCIES

5.1 Apply steps in the problem solving method or process (individual activity).

5.2 Function as an engineer or technologist in problem solving activities.

5.3 Apply mathematical formulas to problems and activities.

5.4 Perform keyboard functions on a scientific, hand-held calculator.

5.5 Input computers and application programs when appropriate for problem solving activities.

CONTENT/CONCEPT	COURSE
5. Working With the Fundamentals of Problem Solving	CHALLENGES IN ENGINEERING

TASK/COMPETENCY

5.1 Apply steps in the problem solving method or process (individual activity)

5.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.1 Given sample design problems and solutions for bridges, 1/8" balsa wood and glue, apply steps in the problem solving method. Model bridge must be tested to a load efficiency rating of .49, using $E = \frac{\text{Failure Weight}}{\text{Length of Wood Used}}$

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.1.1 Identify and observe bridges in photographs, books, slides, and magazines to create interest in bridge design and engineering.

E.5.1.2 Describe different bridge types such as covered, arch, truss, and suspended.

E.5.1.3 Define terms such as stress, shear strength, span, load, elastic, and fracture when discussing why bridges fail.

E.5.1.4 Sketch and design bridge to withstand weight.

E.5.1.5 Construct and test bridge designs.

E.5.1.6 Refine design and construct model bridges.

E.5.1.7 Test model bridge and record data.

E.5.1.8 Calculate efficiency using formula $E = \frac{FW}{L}$

E.5.1.9 Enter Bridge Building Contest at state or national conferences.

E.5.1.10 Reflect a readiness to revise judgements in light of results of research.

CONTENT/CONCEPT

5. Working With the Fundamentals of Problem Solving

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

5.2 Function as an engineer or technologist in problem solving activities.

5.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.2 Given assignments by teacher and sample problems in book, function as an engineer or technologist in problem folving activities that include library and laboratory investigation, record keeping, and reporting.

NABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.2.1 Investigate the work of civil engineers by using libraries and interview techniques.

E.5.2.2 Maintain a log of activities or tasks performed.

E.5.2.3 Cite engineering standards, codes, and graphic techniques.

E.5.2.4 Record data obtained from investigations and tests.

E.5.2.5 Use spoken, graphic, and written communications to report results of problem solving.

CONTENT/CONCEPT

Working With the Fundamentals
of Problem Solving

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

5.3 Apply mathematical formulas to problems and activities.

5.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.3 Given textbook problems and calculator, apply mathematical formulas to problems and activities. Calculations must be according to analysis of problem and teacher's answer key.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.3.1 Describe the modeling process used by engineers to conceptualize a system.

E.5.3.2 Identify a mathematical model as used to analyze and revise a particular system design.

E.5.3.3 Illustrate the concept of system input and output with sketches and equations.

E.5.3.4 Analyze mechanical systems and calculate problems from book, teacher's handouts, or laboratory experiments.

E.5.3.5 Analyze electrical systems and calculate problems from book, teacher's handouts, or laboratory experiments.

E.5.3.6 Analyze fluid systems and calculate problems from book, teacher's handouts, or laboratory experiments.

E.5.3.7 Analyze thermal systems and calculate problems from book, teacher's handouts, or laboratory experiments.

CONTENT/CONCEPT

F Working With the Fundamentals of Problem Solving

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

5.4 Perform keyboard functions on a scientific, hand-held calculator.

5.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.4 Given a scientific calculator, perform keyboard functions to solve problems and determine solutions to numerical tests used in class or laboratory.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.4.1 Perform calculations that result in a word, upside down, on calculator readout.

E.5.4.2 Apply basic logic systems used in calculators to press keys in order.

E.5.4.3 Use special keys on calculator to perform arithmetic functions.

E5.4.4 Use special functions such as roots and powers, reciprocals, factorials, percentages, trig functions, degrees, and radial conversions.

E.5.4.5 Use memory function.

E.5.4.6 Estimate answers to calculations.

E.5.4.7 Solve problems using calculator.

CONTENT/CONCEPT	COURSE
Working With the Fundamentals of Problem Solving	CHALLENGES IN ENGINEERING

TASK/COMPETENCY

5.5 Input computers and application programs when appropriate for problem solving activities.

5.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.5 Given a computer with software, input computer and application problem with appropriate data for problem solving activities. Information must be appropriate to computer function.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.5.1 Identify the components of a computer system such as the processor, monitor, keyboard, disk drives, printer, etc.

E.5.5.2 Follow procedures to turn on, boot up software, and make menu selection.

E.5.5.3 Describe computer and software commands.

E.5.5.4 Use computer for numerical calculations.

E.5.5.5 Select commands to manipulate data and obtain information.

E.5.5.6 Program a computer to accept and analyze data for specific/unique problem.

COURSE: CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

5. Working With the Fundamentals of Problem Solving

EQUIPMENT AND MATERIALS

Graph Paper
Pencil
1/8" x 1/8" Balsa
Model glue
Ruler (12")
Utility knife or single edge razor blades
Testing apparatus
Calculator
Straight pins
Cutting Board
Scientific Calculator and Related Materials
Computer hardware and software

RESOURCES

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Harbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180.
Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Co., NY, 1984.
Calculator Activities, National Council Teachers of Mathematics, Reston, VA.
Problems in Search of a Calculator, NCCCD, 1980
"Bridge Building Contest" rules in AIASA Competitive Events Guidelines
Various bridge books in any library
Careers in Engineering and Technology by Beakley, Chapters 8 & 9
Computer Software

AUDIO-VISUAL MATERIALS

Film: They Said It Couldn't Be Done or film on famous engineering feats such as the Brooklyn Bridge, San Francisco Bay Bridge, Chesapeake Bay Bridge, and many others.

CE5:1
PE5

CONTENT/CONCEPT AREA

6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS.

TASKS/COMPETENCIES

6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.

6.2 Use tools, laboratorty apparatus and equipment to safely determine the properties of materials.

6.3 Conduct laboratory tests and report results in written test report.

6.4 List causes of failure in materials and give procedures used to prevent such failures.

6.5 Explain the concept of supply and demand as it relates to materials in short supply.

6.6 Experiment with processes used with metal, wood, polymer, ceramic, and composite materials and adhesives.

CONTENT/CONCEPT

6. Analyzing the Science and Properties of Materials

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.

6.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.1 Given necessary engineering materials, describe the physical and chemical properties. Description should include at least six (6) properties with definitions.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.1.1 Explain the atomic and molecular structure of materials after watching film, filmstrip.

E.6.1.2 Display samples of materials that fit into these family groups: metallic polyermic, ceramic, composites.

E.6.1.3 Define the term "mechanical property" and give examples after reading handout from teacher.

E.6.1.4 Define the term "chemical property" and give examples after reading handout from teacher.

CONTENT/CONCEPT

6. Analyzing the Science and
Properties of Materials

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.2 Use tools, laboratory apparatus and equipment to safely determine the properties of materials.

6.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.2 Given selected materials and necessary testing devices, use tools, laboratory apparatus and equipment to safely determine the properties of materials. Testing should determine mechanical and chemical properties with 90% accuracy.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.2.1 Define and explain these properties: strength, ductility, hardness, and fatigue strength.

E.6.2.2 Identify the types of stress that can be applied to materials.

E.6.2.3 Exhibit concern for safety in use of chemicals, tools, and equipment after teachers demonstration of testing.

E.6.2.4 Conduct tests to measure tensile strength, elasticity, torsional strength, hardness, and compression strength.

E.6.2.5 Set up chemical tests using proper eye protection.

E.6.2.6 Design and build or modify testing devices needed to safely test for a specific property.

E.6.2.7 Work with care and quality as you conduct investigations and solve problems.

CONTENT/CONCEPT

6. Analyzing the Science and Properties of Materials

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.3 Conduct laboratory tests and report results in written test report.

6.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.3 Given materials to be tested, conduct laboratory tests and report results in written test report. Report should show data collected and discuss results with 90% accuracy.

ENABLING OBJECTIVES AND TLA's TECHNOLOGY LEARNING ACTIVITIES

E.6.3.1 Prepare charts to record data on each test to be conducted.

E.6.3.2 Record data in accurate manner after each material is tested.

E.6.3.3 Prepare charts or graphs to show data collected and results of tests.

E.6.3.4 Write report on results of test by showing data collected.

E.6.3.5 Make a specific gravity test device from tall glass cylinder.

E.6.3.6 Construct a rebound hardness tester to determine relative hardness of different steels, aluminum, copper, etc.

CONTENT/CONCEPT

6. Analyzing the Science and Properties of Materials

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.4 List causes of failure in materials and give procedures used to prevent such failures.

6.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.4 Given examples of problems with materials, list causes of failure in materials and give procedures used to prevent such failure in at least 8 out of 10 examples.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.4.1 Define the terms fatigue, stress, and strain by reading testing information.

E.6.4.2 Define the terms creep, elasticity, yield, and tensile by reading information about mechanical properties.

E.6.4.3 Discuss the failure of sample products which have broken.

E.6.4.4 List the properties of materials and describe the good and poor characteristics of each for specific uses.

E.6.4.5 Discuss ways to prevent corrosion, breakage, and improve strength of objects.

E.6.4.6 Calculate mechanical strength of materials using problems in Introduction to Engineering book by Thomas Blotter.

CONTENT/CONCEPT	**COURSE**
6. Analyzing the Science and Properties of Materials	CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.5 Explain the concept of supply and demand as it relates to materials in short supply.

6.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.5 Given reading materials and teacher's lecture, explain the concept of supply and demand. Explanation should include information about the reasons for specific materials that have demonstrated the concept.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.5.1 List materials used primarily in these technological systems: communications, construction, manufacturing, and production.

E.6.5.2 Discuss reasons for certain materials to become short in supply.

E.6.5.3 Explain how the need to reduce weight has led to the development of new materials.

E.6.5.4 Describe the impact of energy supply and demand on society and people.

E.6.5.5 Discuss the need for recycling of natural materials.

E.6.5.6 Discuss changes in technology about which consumers and citizens should be more informed.

CONTENT/CONCEPT

6. Analyzing the Science and Properties of Materials

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

6.6 Experiment with processes used with metal, wood, polymer, ceramic, and composite materials and adhesives.

6.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.6 Given laboratory tools and machines, experiment with processes used with metal, wood, polymer, ceramic, and composite materials and adhesives. Processes used should be appropriate to models and solutions to be made later in course.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.6.1 Process metallic materials after teacher demonstrations or review.

E.6.6.2 Process wood materials after teacher demonstrations or review.

E.6.6.3 Process ceramic materials after teacher demonstration or viewing audio visual presentations.

E.6.6.4 Process composite materials after teacher demonstration or viewing audio visual presentations.

E.6.6.5 Assemble materials using adhesives appropriate to material and process selected.

E.6.6.6 Demonstrate safe procedures in use of tools, equipment, and materials.

CONTENT/CONCEPT AREA:

6. Analyzing the Science and Properties of Materials

EQUIPMENT AND MATERIALS

Mohs Hardness Test Kit
Tensile Testing Machine

RESOURCES

Guide: Technology Education Instructional Tasks/Competencies for Materials and Processes Technology, VA Department of Education, 1986.

Chapter 5 in Introduction to Engineering by Blotter

Manufacturing: A Basic Text by Fales

"Ceramic Materials" in The Technology Teacher, May/June 1986

"Developing Material Testing Equipment for Specific Needs" in The Technology Teacher, May/June 1985, pp. 28-30.

"New Materials" in The Technology Teacher May/June 1985, pp. 15-22.

"Composite Materials" in The Technology Teacher March 1986. pp. 15-22

"Nature and Properties of Engineering Materials" in The Technology Teacher, Dec. 1985, pp. 15-22.

Technology Education Activities from CITE (Ball State U.)

AUDIO-VISUAL MATERIALS

Film: Metal Crystals in Action from American Society of Metals

CEG:1 on PE 5 disk

CONTENT/CONCEPT AREA

7. WORKING WITH DIFFERENT PROCESSES TO SOLVE PROBLEMS.

TASKS/COMPETENCIES

7.1 Function as a member of a team in problem-solving activities.

7.2 Redesign and test a technical device in small groups.

7.3 Use mathematical symbols to express a relationship between two or more variables.

CONTENT/CONCEPT

COURSE

7. Working with different processes to solve problems.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

7.1 Function as a member of a team in problem-solving activities

7.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.1 Given a small group, students will work together using problem-solving activities to develop processes and use materials for the redesign and testing of a technical device. The problem must be evaluated according to degree of change.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.1.1 The teacher will assign one of the problems listed below:
- A. Bridge using different materials
- B. Mousetrap car
- C. Glider
- D. Beam compass
- E. Others

E.7.1.2 Identify sources of information for acquisition and study.

E.7.1.3 Review engineering steps in design process

E.7.1.4 Have an engineer lecture on the process.

E.7.1.5 Compare engineering design with scientific method and other generalized problem-solving methods.

CONTENT/CONCEPT

7. Working with different processes to solve problems.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

7.2 Redesign and test a technical device in small groups

CODE

7.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.2 Given a technical device, students meeting in a group will design the device in order to preceptively increase its use.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.2.1 List the essential steps in the problem-solving method.

E.7.2.2 Apply the steps in the problem-solving method.

E.7.2.3 Apply the use of different materials in the problem-solving method. (See task 5.1)

E.7.2.4 View problems with objectivity and employ creativity in their solutions.

E.7.2.5 Students will design, construct, and test a model of their problem design.

E.7.2.6 Students will test their solutions.

E.7.2.7 Present an oral and/or written report on problem solving which analyzes factors affecting performance of their solution and write recommendations to overcome these factors. (See task 4.3)

CONTENT/CONCEPT	COURSE
7. Working with different processes to solve problems.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

7.3 Use mathematical symbols to express a relationship between two or more variables.

7.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.3 Given a specific problem the student will use mathematical symbols to express the relationship between two or more variables for the comparison of these variables.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.3.1 Apply mathematical formulas to problems and activites. (See task 5.3)

E.7.3.2 Perform the keyboard functions on a scientific handheld calculator. (See task 5.4)

E.7.3.3 Input computers and applications programs for problem solving. (See task 5.6)

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

7. Using the engineering design process to improve a device or system.

EQUIPMENT AND MATERIALS

Scientific calculator
Computer
Various materials (plaster, wood, metal, paper, glue)
Drafting equipment necessary to produce working drawings
Technology education lab with equipment to produce working model
Mousetrap (4" x 2")

RESOURCES

Introduction to Engineering, Blotter. Chapter 5

Physics textbooks

Textbooks:

Jacobs & Kilduff, Engineering Materials Technology, Prentice-Hall, 1985.

Baily, Disciplined Creativity for Engineers, Ann Arbor Science, Butterworth Group, 1978.

Beakley & Leach, Engineering - An Introduction to a Creative Profession, Macmillan Co., 1972.

Winter, William J., The World of Model Airplanes.

AUDIO-VISUAL MATERIALS

Movie: The Flight of the Gossimer

CONTENT/CONCEPT AREA

8. COMMUNICATING TECHNICAL INFORMATION.

TASKS/COMPETENCIES

8.1 Examine engineering data and discuss the need for communication.

8.2 Write a technical report (or proposal) for an engineering project.

8.3 Use a computer for word processing technical information.

CONTENT/CONCEPT

8. Communicating technical information.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

8.1 Examine engineering data and discuss the need for communication

CODE

8.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.1 Given information contained in bridge building log, examine the engineering data and discuss the need for communication among engineers and clients. Stress the effects of the lack of communication.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.1.1 List times when communications are extremely important to engineering work.

E.8.1.2 Explain some of the ways communication takes place.

E.8.1.3 Discuss effective communication among engineers and between engineers and their clients.

E.8.1.4 Explain the different ways an engineer must be able to communicate with both technical and non-technical people.

E.8.1.5 Deliver a short oral briefing which explains a technical device. (See task 4.3)

E.8.1.6 Use mathematical symbols to express a relationship between two or more variables. (See task 7.3)

E.8.1.7 Describe types of drawings used by engineers.

E.8.1.8 List computer applications used by engineers to communicate.

E.8.1.9 Write letters to request technical information for problem solving and design teams.

CONTENT/CONCEPT	COURSE
8. Communicating Technical Information	CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

8.2 Write a technical report (or proposal) for an engineering project.

8.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.2 Given the data from a current engineering project, write a technical report following the principles of effective communication and complying with industry standards for report writing.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.2.1 Explain proper writing style for an engineering report.

E.8.2.2 Discuss the elements necessary in an engineering report.

E.8.2.3 Follow up the report by evaluating it and then sharing it with other teachers in the school.

E.8.2.4 Use rules for the AIASA Technical Report Writing Contest.

E.8.2.5 Outline a report before writing.

E.8.2.6 For proposal list specific actions that will be taken in the engineering project.

E.8.2.7 For proposal identify results that are expected from the project.

E.8.2.8 For proposal identify who will use the results and when they will be used.

CONTENT/CONCEPT

8. Communicating technical information.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

8.3 Use a computer for word processing technical information.

CODE

8.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.3 Given a microcomputer with word processing software, use a computer to word process technical information. Print out should be clear and with no more than two errors per page.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.3.1 Explain steps to boot up the computer.

E.8.3.2 Set margins for type of page to be typed and standards to be followed.

E.8.3.3 Keyboard in all written information.

E.8.3.4 Keyboard in all engineering data.

E.8.3.5 Use commands to modify file and information.

E.8.3.6 Printout information.

E.8.3.7 Proofread and revise information in the computer.

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

8. Communicating technical information.

EQUIPMENT AND MATERIALS

Micro-computer and printer
Word processing software

RESOURCES

Handbook for writing standards.

AUDIO-VISUAL MATERIALS

Movie: Reporting and Briefing, Centron Films, Inc.

CONTENT/CONCEPT AREA

9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM.

TASKS/COMPETENCIES

9.1 Select a problem or project for improvement.

9.2 List essential steps in the design process.

9.3 use the steps in the design process to improve a product.

CONTENT/CONCEPT	COURSE
9. Using the design process to improve a device or system.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
9.1 Select a problem or project for improvement.	

9.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.9.1 Given a list of problems, select a project that can be improved in quality. performance, and/or appearance and submit one to five ideas for modification.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.9.1.1 Examine the problem and determine other uses the idea can be put into function.

E.9.1.2 Examine the problem and determine whether it can be combined with another idea.

E.9.1.3 List the disadvantages of the problem.

E.9.1.4 List the advantages of the problem.

E.9.1.5 List five "highly desirable" alterations that would encourage personal travel by rail.

E.9.1.6 Describe some design that you believe defies improvement.

CONTENT/CONCEPT

9. Using the design process to improve a device or system.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

9.2 List essential steps in the design process.

CODE

9.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.9.2 When describing engineering problem solving methodology, list the steps in the design process. Steps must be listed in order; however, the specific words describing each step may vary according to the source reference.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.9.2.1 Explain that engineers use a formal systematic approach to problem solving.

CONTENT/CONCEPT	COURSE
9. Using the design process to improve a device or system.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
9.3 Use the steps in the design process to improve a product.	

9.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.9.3 Given a problem or product to be improved, use the steps in the design process. Steps must be used in sequence, but recycling may occur at any point.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.9.3.1 Given a problem or product to be improved, formulate the problem statement.

E.9.3.2 Conduct systematic research to collect information on the problem.

E.9.3.3 Use a method such as "brainstorming" to generate ideas.

E.9.3.4 Explain the different ways that a solution can be modeled.

E.9.3.5 Using a systematic approach evaluate possible problem solutions.

E.9.3.6 Design and conduct experiments to test problem solutions.

E.9.3.7 Effectively communicate the solution of a problem.

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

9. Using the design process to improve a device or system.

EQUIPMENT AND MATERIALS

RESOURCES

Books:

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science Publishers, Ann Arbor, Michigan.

Beakley, George C., Careers in Engineering and Technology, Macmillan Publishing Co., New York.

AUDIO-VISUAL MATERIALS

CONTENT/CONCEPT AREA

10. RESEARCHING TECHNICAL LIBRARY AND PATENT INVENTION INFORMATION.

TASKS/COMPETENCIES

10.1 Identify informational references found in a technical library.

10.2 Locate reference books, dictionaries, and periodicals used by engineers.

10.3 Discuss the six legal categories of patents.

10.4 Explain how patents are obtained.

10.5 Describe how patents protect the inventor.

ONTENT/CONCEPT

COURSE

10. Researching technical library and patent/ invention information.

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

10.1 Identify informational references found in a technical library.

10.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.10.1 **After reviewing previously learned library search skills the student will demonstrate a working knowledge of the technical library section by locating five technical library materials and select one resource to write a report on a single topic.**

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.10.1.1 Identify the three basic sections of a typical library.

E.10.1.2 List references that the library has in its collection in technical categories.

E.10.1.3 List three technical or scientific journals held in the library.

E.10.1.4 Synthesize information from multiple sources to prepare a research paper (Standards of Learning (SOL) Objective 11.4 - Library Information Use).

E.10.1.5 Demonstrate proficiency in information gathering skills (Standards of Learning (SOL) Objective 12.1 - Library Information Use).

E.10.1.6 Recognize alternative systems for organizing and accessing information (Standards of Learning (SOL) Objective 12.3 - Library Information Use).

ONTENT/CONCEPT	**COURSE**
10. Researching technical library and patent/ invention information.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

10.2 Locate reference books, dictionaries, and periodicals used by engineers.

10.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.10.2 Given a scientific or technical reserarch topic select appropriate resources to find information used by engineers on the given topic and list the sources.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.10.2.1 Name two engineering societies from which publications may be obtained.

E.10.2.2 Find an article published in an engineering journal within the last six months on the subject of composite materials. Copy the citation.

E.10.2.3 Find the manufacturer's catalog for a company that produces ball bearings. List the source.

E.10.2.4 Find the definition and illustration of the term "magnetohydrodynamic generator". List the source.

E.10.2.5 Identify and use community resources, et., library,, institutions, engineering firms, and societies (Standards of Learning (SOL) Objective 11.3 - Library Information Use).

E.10.2.6 Synthesize information from multiple sources to preapre a research report (Standards of Learning (SOL) Objective 11.4 - Library Information Use).

ONTENT/CONCEPT

10. Researching technical library and patent/invention information.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

10.3 List the six legal categories of patents.

CODE

10.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.10.3 Upon reviewing patent resources, list six legally-acceptable categories that qualify as patentable and describe the meaning of process patent; machine patent; method of manufacturing patent; composition patent; living plant patent; and design patent.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.10.3.1 Visit the nearest library and ascertain the number of books in the collection dealing with patents, inventions, trademarks, and copyrights. Write a detailed definition of each of the above.

E.10.3.2 Name six types of innovation that may be patented and describe each.

E.10.3.3 Illustrate how a manufacturing process consisting of a number of commonly known steps can be modified by an innovation that is new and useful such that a new patent can be applied for and subsequently issued to the inventor by the U.S. Patent Office.

E.10.3.4 Cite an example of an innovation to an existing machine that was or could be patented by its inventor.

E.10.3.5 Visit or write IFI/Plenum Data Corporation, Alexandria, Virginia, to review their databases that provide information on the current status of U.S. Patents.

E.10.3.6 Visit or write NTIS (National Technical Information Service) (U.S. Department of Commerce) in Springfield, Virginia to review their multidisciplined database dealing with government-sponsored research, development, and engineering reports which are available to the public.

CONTENT/CONCEPT

10. Researching technical library and patent/ invention information.

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

10.4 Explain how patents are obtained.

CODE

10.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.10.4 Given resources for obtaining a patent, make a working model of a device in one of the six patent categories and mock the process of obtaining a patent with appropriate documentation. (Note: If permissable and practical go through the legal and economic process of actually obtaining a patent.)

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.10.4.1 List the steps in a patent search.

E.10.4.2 Select an invention and describe the patent drawings and legal papers.

E.10.4.3 Present an oral report during a class seminar.

E.10.4.4 Discuss whether or not a patent can be transferred to another person.

E.10.4.5 Discuss the legality of a person inheriting a patent.

E.10.4.6 Visit the nearest patent counsel (NASA research centers or private corporations) to determine the procedure for applying for a patent and the attendant costs, if any.

E.10.4.7 Describe the difference between a patent lawyer and a patent agent.

E.10.4.8 Obtain a copy of a patent from any of a number of sources such as U.S. Patent office, local libraries, or corporations and identify the nine components of a patent.

E.10.4.9 Discuss the requirements of a patent search.

E.10.4.10 List the many sources of technical information (summaries, drawings, abstracts, microfilms, encyclopedias, databases) available to the individual inventor in his search of the literature.

E.10.4.11 Visit the nearest library and ascertain the number of books in the collection dealing with patents, inventions, trademarks, and copyrights. Write a detailed definition of each of the above.

CONTENT/CONCEPT	**COURSE**
10. Researching technical library and patent/ invention information.	CHALLENGES IN ENGINEERING
TASK/COMPETENCY	**CODE**
10.5 Describe how patents protect the inventor.	

10.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.10.5 Given a problem of obtaining a patent for an invention and upon making a working model of a device (assigned in 10.4) interview a patent lawyer on protecting your invention.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.10.5.1 Describe how copyrights protect authors and publishers.

E.10.5.2 Discuss the rights of inventors who work for a corporation.

E.10.5.3 Contact and interview two engineers and validate the new and uniqueness of your model.

E.10.5.4 Outline the filing application procedures.

E.10.5.5 Estimate the approximate cost to patent your model.

E.10.5.6 Estimate the approximate time span to patent your model.

E.10.5.7 Visit the nearest library and ascertain the number of books in the collection dealing with patents, inventions, trademarks, and copyrights. Write a detailed definition of each of the above.

CONTENT/CONCEPT AREA

11. COMPUTING DATA FOR SOLVING PROBLEMS

TASKS/COMPETENCIES

11.1 Perform the keyboard functions on a scientific, hand-held calculator.
(See task #5.4 for resource form.)

11.2 Use computers and application programs when appropriate for problem-solving activities (should add more computer science here).
(See task 3.12 for resource form.)

11.3 Apply mathematical formulas to problems and activities.
(See task 5.3 for resource form.)

11.4 Use mathematical symbols to express a relationship between two or more variables.
(See task 7.3 resource form.)

CONTENT/CONCEPT AREA

12. INTRODUCING THE TEAM CONCEPT AND THE ENGINEERING DESIGN PHASE (IN SECOND COURSE).

TASKS/COMPETENCIES

12.1 Recall the members of the technological team and the steps in the problem-solving process.

12.2 List the reasons and steps for a feasibility study.

12.3 List the essential steps in the preliminary design phase.

12.4 List the essential steps in the detailed design phase.

12.5 Present overview of the group method to relate the importance of teamwork for problem solving.

12.6 Brainstorm and select possible problem-solving activities for feasibility study.

ONTENT/CONCEPT

COURSE

12. Introducing the team concept and the engineering design phase (in second course).

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

CODE

12.1 Recall the members of the technological team and the steps in the problem-solving process.

12.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.1 Given textbook readings, recall the members of the technological team and the steps in the problem-solving process by summarizing the duties of each team member and define the meaning of each of the problem-solving processes.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.1.1 List the five members of the technological team.

E.12.1.2 List the eight steps of the problem-solving process.

E.12.1.3 Define the duties of each member of the technological team.

E.12.1.4 Explain the importance of applying the problem-solving process by the technological team to solve a problem.

E.12.1.5 Define each step of the problem-solving process.

CONTENT/CONCEPT **COURSE**

12. Introducing the team concept of the engineering design phase (in second course). CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

12.2 List the reasons and steps for a feasibility study.

12.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.2 Given textbook readings, list the reasons for conducting a feasibility study and define each step.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.2.1 Define a feasibility study.

E.12.2.2 Describe how the feasibility study is used in the design phase.

E.12.2.3 Discuss the objectives of a feasibility study.

E.12.2.4 Have an engineer discuss and demonstrate the importance of this design phase.

CONTENT/CONCEPT **COURSE**

12. Introducing the team concept of the engineering design phase (in second course).

CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

12.3 List the essential steps in the preliminary design phase.

12.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.3 Given the appropriate text and assistance list the steps in the preliminary design phase and define each one.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.3.1 Define a preliminary design.

E.12.3.2 Discuss the importance of a preliminary design.

E.12.3.3 Have an engineer discuss and demonstrate the importance of this design phase.

CONTENT/CONCEPT	COURSE
12. Introducing the team concept of the engineering design phase (in second course).	CHALLENGES IN ENGINEERING

TASK/COMPETENCY CODE

12.4 List the essential steps in the detailed design phase.

12.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.4 Given the appropriate texts list the steps in the detailed design phase and briefly define each.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.4.1 Define a detailed design.

E.12.4.2 Identify the components of a detailed design.

E.12.4.3 Discuss the importance of a detailed design.

E.12.4.4 Have an engineer discuss and demonstrate the importance of this design phase.

CONTENT/CONCEPT

12. Introducing the team concept of the engineering design phase (in second course)

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

12.5 Present overview of the group method to relate the importance of teamwork for problem solving.

CODE

12.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.5 Given a slide and film presentation on the group method students will present a list of facts depicting the importance of teamwork as it relates to problem solving.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.5.1 Define the term seminar.

E.12.5.2 List the essential steps in organizing the group method.

E.12.5.3 State the importance of a personnel system.

E.12.5.4 Explain how the group method encourages teamwork.

CONTENT/CONCEPT **COURSE**

12. Introducing the team concept and the engineering design phase (in second course). CHALLENGES IN ENGINEERING

TASK/COMPETENCY **CODE**

12.6 Brainstorm and select possible problem-solving activities for a feasibility study.

12.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.12.6 Given the appropriate information and instructions students will brainstorm and select three problem-solving activities and apply the feasibility study to each.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.12.6.1 Define the term feasibility.

E.12.6.2 Define the problem-solving process.

E.12.6.3 List all possible problems on the chalkboard.

E.12.6.4 Select three problems to be solved using the democratic process.

E.12.6.5 Conduct a feasibility study on each of the selected problems.

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

12. Introducing the team concept and the engineering design phases.

EQUIPMENT AND MATERIALS

RESOURCES

Beakley, George C., Careers in Engineering and Technology, Macmillan Publishing Company, New York.

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science Publishers, Ann Arbor, Michigan.

AUDIO-VISUAL MATERIALS

CONTENT/CONCEPT AREA

13. BRIEFING OTHERS ON RESULTS OF ENGINEERING.

TASKS/COMPETENCIES

13.1 Present an oral report on problem-solving activities.

13.2 Pre-register for competitive events.

13.3 Prepare a written technical report on problem-solving activities.

13.4 Construct a display of activities to use in a public location.

CONTENT/CONCEPT	COURSE
13. Briefing others on results of engineering.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
13.1 Present an oral report on problem-solving activities.	

13.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.13.1 Upon completion of a problem the student will organize and present an oral report on the activities of the problem solved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.13.1.1 Request assistance from math, science, and english teachers to assist students on problem solving activity.

E.13.1.2 Appoint an advisory committee to help with resources.

E.13.1.3 Organize a seminar for students to give oral reports on their problem-solving activity to advisory committee, other teachers, and other students; prepare invitations, announcements flyers.

E.13.1.4 Display student work before and after seminar.

E.13.1.5 Give recognition to consultants for assistance and attendance.

CONTENT/CONCEPT	COURSE
13. Briefing others on results of engineering.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
13.2 Pre-register for competitive events.	13.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.13.2 Given the rules and criteria for local, region, state, and national competitive events, students will select events related to engineering problems solved and pre-register for appropriate competition using the criteria and rules for entry as the standards.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.13.2.1 Review the rules and criteria for competitive events of appropriate engineering problems solved.

E.13.2.2 Complete pre-registration forms for appropriate competitive events.

E.13.2.3 Prepare materials and problem solved for entry according to the standards of the event.

CONTENT/CONCEPT

13. Briefing others on results of engineering

COURSE

CHALLENGES IN ENGINEERING

TASK/COMPETENCY

13.3 Prepare a written technical report on problem-solving activities.

CODE

13.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.13.3 Upon completion of a problem the student will organize and present a written report on the activities of the problem solved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.13.3.1 Request assistance from math, science, and english teachers to assist students on problem-solving activity.

E.13.3.2 Appoint an advisory committee to help with resources.

E.13.3.3 Present the written technical report to the advisory committee for critique and/or competition.

E.13.3.4 Display student work before and after written technical report.

E.13.3.5 Give recognition to consultants for assistance and attendance.

CONTENT/CONCEPT	COURSE
13. Briefing others on results of engineering.	CHALLENGES IN ENGINEERING

TASK/COMPETENCY	CODE
13.4 Construct a display of activities to use in a public location.	

13.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.13.4 Given materials for exhibit, construct a display of activities of problems solved to use in public locations, to communicate the program.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.13.4.1 Organize, design, and select materials and construct a display.

E.13.4.2 Involve student in selecting a site for display of problem-solving projects and design activities, e.g., mall, school board office, bank buildings, etc.

E.13.4.3 Obtain permission for date and location from proper authorities.

E.13.4.4 Write news release for local papers to announce the display and list all students and their projects.

E.13.4.5 Prepare display for competition in regional, state, and national events according to the criteria for the event.

CHALLENGES IN ENGINEERING

CONTENT/CONCEPT AREA:

18. Briefing others on the results of engineering.

EQUIPMENT AND MATERIALS

RESOURCES

Rules and Criteria for Virginia and National Contests 1987.
Identifies permanent rules for Regional Fairs and the Virginia Spring Festival and National Conference.
Order from: Technology Education Service, P.O. Box 6Q, Richmond, VA 23216

Competitive Events Guidelines 1985.
Order from: AIASA National Office
1908 Association Drive, Reston, VA 22091
Cost: $3

AIASA Member Guide
Order from: AIASA National Office
See above
Cost: $25 (Pkg. of 30)

AIASA Chapter Handbook
Order from: AIASA National Office
See above
Cost: $4

AUDIO-VISUAL MATERIALS

Movie: Reporting & Briefing, Centron Films, Inc.

CONTENT/CONCEPTS
FOR
ENGINEERING PROJECTS

1. RELATING THE OBJECTIVES OF COURSE TO STUDENTS AND SOCIETY.
2. REVIEWING THE TECHNOLOGICAL TEAM AND RELATED CAREERS.
3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY.
4. OBSERVING DESIGNS IN NATURE.
5. REVIEWING THE ENGINEERING DESIGN PHASES.
6. USING THE DESIGN PROCESS AS A GROUP STUDY.
7. COMMUNICATING THROUGH PROPOSALS, GRAPHICS, COMPUTERS, AND REPORTS.
8. BRIEFING OTHERS ON RESULTS OF ENGINEERING.

CONTIIC/C
INTRO TO ENGR LB2

CONTENT/CONCEPT AREA

1. RELATING OBJECTIVES OF COURSE TO STUDENTS AND SOCIETY.

TASKS/COMPETENCIES

1.1 List courses that help an engineer work with, for, and communicate with people.

1.2 List ways an engineer can prevent his/her knowledge and skills from becoming obsolete.

1.3 Discuss the impact of engineering on society and the environment.

1.4 Identify appropriate community activities for engineers.

CONTENT/CONCEPT	COURSE
1. Relating objectives of course to students and society.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
1.1 List courses that help an engineer work with, for, and communicate with people.	

1.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.1.1 Given a copy of the school('s) courses, list the courses that help an engineer work with, for, and communicate with people.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.1.1 Explain nature of engineer's work from information gathered from reference text and the teacher's lecture.

E.1.1.2 List courses that would include activities similar to those of an engineer.

E.1.1.3 Interview engineers and discuss with them their background and training.

CONTENT/CONCEPT

1. Relating objectives of course to students and society.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

1.2 List ways an engineer can prvent his/her knowledge and skills from becoming obsolete.

CODE

1.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.2.1 Given information concerning updating activities, list (at least 85% of) the ways an engineer may prevent his/her knowledge and skills from becoming obsolete.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.2.1 Explain the effects of rapid technology expansion on an engineer's performance ability.

E.1.2.2 Evaluate various means of information up-dating such as: periodicals, classes, seminars, and visitation.

E.1.2.3 Write to the American Society of Professional Engineers and obtain information concerning knowledge and skills up-dating.

CONTENT/CONCEPT

COURSE

1. Relating objectives of course to students and society.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

1.3 Discuss the impact of engineering on society and the environment.

1.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.3.1 Given a presentation by a local engineer, cite ways the work of the engineer affects people and the environment.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.3.1 Explain the nature of an engineer's work as it relates to people and the environment.

E.1.3.2 Attend a meeting of a local engineering society and observe activities that members are involved in.

E.1.3.3 Observe and write about an engineering project and it's impact on the people and the environment of the area.

CONTENT/CONCEPT

COURSE

1. Relating objectives of course to students and society.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

1.4 Identify appropriate community activities for engineers.

1.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.1.4.1 Considering the Engineering Profession's Code of Ethics, identify specific examples of community service and what percentage of their time is spent in this manner.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.1.4.1 Describe the community service aspects of the engineering profession.

E.1.4.2 Conduct an interview with an engineer and discuss with him/her the role that community service plays in the engineering profession and Code of Ethics.

CONTENT/CONCEPT AREA:

1. Relating objectives of course to students and society.

EQUIPMENT AND MATERIALS

Overhead Projector
Slide/Tape Projector

RESOURCES

Beakley, George C., Careers in Engineering and Technology 3rd edition.

A.V./Handout: "Important Questions for Potential Engineers" by Kenneth Anderson, Anderson Associates, Inc., Blacksburg, Virginia. (engineering consultant).

AUDIO-VISUAL MATERIALS

Slide/Tape: Engineering: An Introduction to the Field and Its Careers by Dr. James A. Jacobs, 1985.

EP

CONTENT/CONCEPT AREA

2. REVIEWING THE TECHNOLOGICAL TEAM AND RELATED CAREERS.

TASKS/COMPETENCIES

2.1 List the members of the technological team and describe their responsibility.

2.2 Describe the formal educational background of the engineering technologist.

2.3 Write the definition of an engineer..

2.4 Discuss ways that all engineers are managers.

2.5 List the levels of management wherein an engineer might work alternate. List the levels of management of an engineer.

CONTENT/CONCEPT

2. Reviewing the technological team and related careers.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

2.1 List the members of the technological team and describe their responsibility.

CODE

2.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.1.1 Given the resources of the occupational spectrum, list and describe five members of the technological team and their responsibility.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.1.1 Review the responsibility of the technological team:
Craftsman, technician, technologist, engineer, and scientist (Careers in Engineering & Technology - Beakley pg. 28-39)

E.2.1.2 Interview each member of the technological team.

E.2.1.3 Classify assignments that are typical of each of the technological team.

E.2.1.4 Role play or actually perform a task that one of the technological team members would perform.

E.2.1.5 Show slide/tape "Introduction to Engineering and Their Careers" - Jacobs

CONTENT/CONCEPT

COURSE

2. Reviewing the technological team and related careers.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

2.2 Describe the formal edcuational background of the engineering technologist.

2.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.2.1 After reviewing the roles of and/or interviewing an engineering technologist describe their formal educational background and list two career opportunities after college preparation.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.2.1 Investigate the differences in educational requirements of an engineer and the technician.

E.2.2.2 Investigate opportunities in the community for electronic technicians.

E.2.2.3 Investigate the largest industry in the community and identify the number of engineers and technicians employed.

E.2.2.4 Invite guest engineers, technicians, technologists to speak in the class.

E.2.2.5 Show slide/tape----

CONTENT/CONCEPT

2. Reviewing the technological team and related careers.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

2.3 Write the definition of an engineer.

CODE

2.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.3.1 Given resources describing the engineer writethe definition of an engineer according to the "Society of Professional Engineers."

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.3.1 Memorize the definition of an engineer as defined by the "Society of Professional Engineers."

E.2.3.2 Compare the definition of an engineer with the "Society of Procfessional Engineers"; Introduction to Engineering by Blotter, and a dictionary.

E.2.3.3 Describe the major differences in the definitions of E.2.3.2.

CONTENT/CONCEPT

2. Reviewing the technological team and related careers.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

2.4 Discuss ways that all engineers are managers.

CODE

2.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.4.1 Given the information on the role of the engineer, discuss ways that all engineers are managers and list two management functions related to their jobs.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.4.1 Review the responsibility of the technological team: Craftsman, technician, technologist, engineer, and scientist (Careers in Engineering & Technology - Beakley pg. 28-39).

E.2.4.2 Interview each member of the technological team.

E.2.4.3 Classify assignments that are typical of each of the technological team.

E.2.4.4 Role play or actually perform a task that one of the technological team members would perform.

E.2.4.5 Memorize the definition of an engineer as defined by the "Society of Professional Engineers."

E.2.4.6 Show slide/tape "Introduction to Engineering and Their Careers" - Jacobs

E.2.4.7 Invite guest engineers, technicians, technologists to speak in the class.

CONTENT/CONCEPT
2. Reviewing the technological team and related careers.

COURSE
ENGINEERING PROJECTS

TASK/COMPETENCY
2.5 List the levels of management wherein an engineer might work alternate. List the levels of management of an engineer.

CODE
2.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.2.5.1 Given the Directory of Professional Engineering Societies, list the levels of management of engineers in two engineering fields and five specific management responsibilities.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.2.5.1 List the engineering fields recognized by the state registration board for licensing as professional engineers.

E.2.5.2 List the levels of engineering that require a licensed professional engineer.

E.2.5.3 Identify five professional technical societies related to the engineering profession.

E.2.5.4 Relate the management roles of the officer of the student organization with similar management roles of an engineer.

CONTENT/CONCEPT AREA:

2. Reviewing the technological team and related careers.

EQUIPMENT AND MATERIALS

35mm Slide Projector
Cassette Tape Recorder (synchronized if possible)
Screen

RESOURCES

1. Bailey, Robert L., Disciplined Creativity for Engineers, Ann Harbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180

2. Beakley, George C., Careers in Engineering and Technology, Third Edition, MacMillan Publishing Co., NY, 1984.

3. Blotter, Thomas P., Introduction to Engineering, John Wiley & Sons, 1 Wiley Drive, Somerset, NJ 08873, (201) 469-4400.

Advisor's Handbook 1987.
Includes sections on organizing a school chapter on leadership development, meeting procedures, committees, and conference participation.
Order from: Technology Education Service, VA Dept. of Education
P.O. Box 6Q, Richmond, VA 23216

Officer's Handbook 1981.
Includes sections on leadership development, meeting procedures, committees, and conference participation.
Order from: Technology Education Service - See Address Above.

Engineering Professional/Technical Societies List on pg. 95-96, Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Co., NY, 1984.

National Society of Professional Engineers, 2029 K. Street, N.W.,
Washington, DC 20006

AUDIO-VISUAL MATERIALS

Slide/Tape: Engineering: An Introduction to the Field and Its Careers, by Dr. James A. Jacobs, developed for the Introduction to Engineering Curriculum Research Project. Available through the Technology Education Service, see address above.

EP

CONTENT/CONCEPT AREA

3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY.

TASKS/COMPETENCIES

3.1 Identify and describe engineering problems and their solutions.

3.2 Describe the application of mathematics in the solution of engineering problems.

3.3 Describe the application of scientific principles in the solution of engineering problems.

3.4 Describe the application f technology in the solution of engineering problems.

3.5 Utilize tools, machines, and equipment safely.

3.6 Prepare a model of the solution of an engineering problem.

3.7 Use engineering graphics to describe the solution of an engineering problem.

3.8 Describe the social, cultural, and environmental impact of an engineering project.

3.9 Present an oral report on the solution of an engineering problem.

CONTENT/CONCEPT	COURSE
3. Preparing a formal seminar on an engineering case study.	ENGINEERING PROJECTS II

TASK/COMPETENCY	CODE
3.1 Identify and describe engineering problems and their solutions.	3.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.1.1 After studying an engineering project, identify and describe associated engineering problems and their solutions,. At least three problems and their solutions must be included.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.1.1 Analyze case study resources to identify specific engineering design/implementation problems and their solutions.

CONTENT/CONCEPT

3. Preparing a formal seminar on an engineering case study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

3.2 Describe the application of mathematics in the solution of engineering problems.

3.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.2.1 After studying an engineering problem, describe the mathematics used in the solution of the problem. Description must include equations or specific principles involved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.2.1 Analyze engineering problems and solutions described in case study resources to identify specific applications of mathematics.

CONTENT/CONCEPT

3. Preparing a formal seminar on an engineering case study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

3.3 Describe the application of scientific principles in the solution of engineering problems.

CODE

3.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.3.1 After studying an engineering problem, describe the scientific principles used in the solution of the problem. Description must include specific laws and equations involved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.3.1 Analyze engineering problems and solutions described in case study resources to identify specific applicaitons of scientific principles.

CONTENT/CONCEPT	COURSE
3. Preparing a formal seminar on an engineering case study.	ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

3.4 Describe the application of technology in the solution of engineering problems.

3.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.4.1 After studying an engineering problem, describe the technology used in the solution of the problem. Description must include specific processes and materials.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.4.1 Analyze engineering problems and solutions described in case study resources to identify specific applications of technology.

CONTENT/CONCEPT

3. Preparing a formal seminar on an engineering case study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

3.5 Utilize tools, machines, and equipment safely.

CODE

3.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.5.1 While working in the technology education lab, utilize tools, machines, and equipment safely. Safe utilization includes a demonstrated knowledge of safety rules through practical and written safety tests.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.5.1 Describe the importance of safety when working with tools and machines and develop attitudes and good work habits.

E.3.5.2 Name major parts of tools and machines used and list rules for safe use as it relates to personal safety, general safety, hand tool safety, and machine safety.

E.3.5.3 Investigate typical work functions of an engineer and prepare a brief report on related tasks involving safe practices.

E.3.5.4 Describe safety applications and responsibilities in regard to the following engineering functions:

Management
Industry
Operation
Maintenance
Research
Construction
Production
Design
Development

CONTENT/CONCEPT | **COURSE**

3. Preparing a formal seminar on an engineering case study.

ENGINEERING PROJECTS

TASK/COMPETENCY | **CODE**

3.6 Prepare a model of the solution of an enginering problem.

3.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.6.1 Having selected a specific engineering problem and its solution, prepare a model demonstrating the problem and its solution. The model may be physical, a computer simulation, or demonstration of principles using scientific apparatus.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.6.1 Describe at least four different ways that an object or a system can be modeled.

E.3.6.2 Identify models used daily by society and explain why they are used.

CONTENT/CONCEPT

3. Preparing a formal seminar on an engineering case study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

3.7 Use engineering graphics to describe the solution of an engineering problem.

3.7

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.7.1 Having selected a specific engineering problem and its solution, use engineering grapahics to describe the problem and its solution. The graphics may be completed using manual or computer aided drafting, but must include at least one orthographic projection and one pictorial view.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.7.1 Draw and interpret objects in orthographic projection.

E.3.7.2 Draw and interpret objects in isometric or oblique projection.

E.3.7.3 Use graphs and empirical equations to describe physical phenomenon.

E.3.7.4 Use a computer aided drafting system to produce engineering graphics.

CONTENT/CONCEPT

3. Preparing a formal seminar on an engineering case study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

3.8 Describe the social, cultural, and environmental impact of an engineering project.

CODE

3.8

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.8.1 After studying an engineering project, describe its social, cultrual, and environmental impact. This description must include an analysis of the impact of these factors upon the design of the project.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.8.1 Analyze engineering problems and solutions described in case study resources to identify social, cultural, and environmental impacts.

E.3.8.2 Explain how engineering design is affected by projected social, cultural, and environmental impacts.

CONTENT/CONCEPT	**COURSE**
3. Preparing a formal seminar on an engineering case study.	ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

3.9 Present an oral report on the solution of an engineering problem.

3.9

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.3.9.1 After studying an engineering project, present an oral report on the solution of an engineering problem. This presentation must include the use of appropriate visual aids including a model and engineering graphics.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.3.9.1 List techniques that contribute to an effective oral presentation.

E.3.9.2 List things that detract from the effectiveness of an oral presentation.

E.3.9.3 Explain how to prepare an effective outline for an oral presentation.

CONTENT/CONCEPT AREA:

3. Preparing a formal seminar on an engineering case study.

EQUIPMENT AND MATERIALS

Technical drawing equipment and supplies.

Computer Aided Drafting System

RESOURCES

Engineering case studies.

A high school chemistry text.

A high school biology text

One copy of each mathematics text used in your high school.

Technical drawing texts used in your high school.

Books:

Betts, John E., Physics for Technology, Reston Publishing Company, Inc., Prentice-Hall Company, Reston, VA.

Physics for Technicians, The Center for Occupational Research and Development, Waco, TX.

Beakley, George C., Careers in Engineering and Technology, Macmillan Publishing Co., NY.

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science Publishers, Ann Arbor, MI.

AUDIO-VISUAL MATERIALS

Movie: Reporting and Briefing, Centron Films, Inc.

CONTENT/CONCEPT AREA

4. OBSERVING DESIGNS IN NATURE.

TASKS/COMPETENCIES

4.1 Describe examples of products made from natural materials that have used the engineer's knowledge of the characteristics of natural materials.

4.2 Identify examples of engineering designs that attempt to duplicate structure of plants.

4.3 Discuss the design of human and animal bones and their resistance to torsion.

4.4 List examples of functional design in animals such as birds and reptiles.

4.5 Identify the honeycomb structure in nature and engineering designs.

CONTENT/CONCEPT

4. Observing designs in nature.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

4.1 Describe examples of products made from natural materials that have used the engineer's knowledge of the characteristics of natural materials.

CODE

4.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.1.1 Given a list of five natural materials, the student will describe the uses and properties of at least four materials so that its use or application is justified.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.1.1 Observe local examples of human's use of natural material products designed with consideration to their characteristics.

E.4.1.2 List your observations of human's use of natural materials and justify their use.

E.4.1.3 Compare/combine the lists of all the students in the class.

CONTENT/CONCEPT	COURSE
4. Observing designs in nature.	ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

4.2 Identify examples of engineering designs that attempt to duplicate structure of plants.

4.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.2.1 Given a list of five engineering designs, the student will select a plant on which the structure was based and establish a matching correlation to justify its selection (for at least four).

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.2.1 Study the following plant structures:
Dandylion, bamboo

E.4.2.2 Look for relationships between engineering designs and natural occuring structures.

E.4.2.3 Contact local engineering firms and ask if they have developed any projects based on natural occuring structures.

CONTENT/CONCEPT

4. Observing designs in nature.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

4.3 Discuss the design of human and animal bones and their resistance to torsion.

CODE

4.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.3.1 Given information on the physical structure of human and animal bones, the student will relate this to resistance to torsion, and support the relation by demonstrated physical activities.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.3.1 Examine skeletons from both animals and humans.

E.4.3.2 Test properly obtained bone samples for compressive and tension strengths.

E.4.3.3 Study medical records concerning accidents and injury to bones to determine strengths and weaknesses.

CONTENT/CONCEPT

4. Observing designs in nature.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

4.4 List examples of functional design in animals such as birds and reptiles.

CODE

4.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.4.1 Having been given a lesson, the student will from memory list at least four functional design examples occuring in birds and reptiles.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.4.1 Question the biology teacher concerning examples of functional design in birds and reptiles.

E.4.4.2 Contact the local ornithologic chapter and see if they can arrange an appropriate guest speaker.

CONTENT/CONCEPT **COURSE**

4. Observing designs in nature. ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

4.5 Identify the honeycomb structure in nature and engineering designs.

4.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.4.5.1 Given a description (definition) of a honeycomb structure the student will identify three examples in nature and engineering designs, to the extent that all three will be self evident.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.4.5.1 Through research list examples of five honeycomb structures in nature and man's engineering.

E.4.5.2 Find out how a honeycomb structure was used on the Surveyor space craft.

CONTENT/CONCEPT AREA:

4. Observing designs in nature.

EQUIPMENT AND MATERIALS

Animal Bones/Skeleton Parts

RESOURCES

Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Co., NY, 1984, Chapter 10.

AUDIO-VISUAL MATERIALS

CONTENT/CONCEPT AREA

5. REVIEWING THE ENGINEERING DESIGN PHASES.

TASKS/COMPETENCIES

5.1 Define and list steps in the engineering design processes.

5.2 Define what an "optimum design" is and why one rarely exists.

5.3 List the three phases used in most engineering designs.

5.4 Describe the objectives of the feasibility study.

5.5 Explain the use of the evaluation table in selecting the best alternative to develop in detail during the preliminary design phase.

CONTENT/CONCEPT

5. Reviewing the engineering design phases.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

5.1 Define and list steps in the engineering design processes.

CODE

5.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.1.1 Given information and reading assignments, define and outline each segment of the engineering design process.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.1.1 Talk to an engineer who is working in design or development in industry.

E.5.1.2 Define the engineering design process.

E.5.1.3 Compare engineering design with scientific method and other problem-solving methods.

CONTENT/CONCEPT **COURSE**

5. Reviewing the engineering design phases. ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

5.2 Define what an "optimum design" is and why one rarely exists.

5.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.2.1 Given textbook readings, define what an optimum design is and explain why one rarely exists.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.2.1 Discuss the elements of good design.

E.5.2.2 Discuss the possible limitations in designing products.

E.5.2.3 Discuss why the optimum design is difficult to achieve.

CONTENT/CONCEPT

COURSE

5. Reviewing the engineering design phases.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

5.3 List the three phases used in most engineering designs.

5.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.3.1 Given textbook readings, list the three phases used in the engineering design and define each.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.3.1 List the three engineering design phases.

E.5.3.2 Define each of the design phases.

E.5.3.3 Explain the necessity for each of the phases.

E.5.3.4 Discuss how each of the design phases interelate.

CONTENT/CONCEPT	COURSE
5. Reviewing the engineering design phases.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
5.4 Describe the objectives of the feasibility study.	5.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.4.1 Given textbook readings, describe the objectives of the feasibility study and give an example of each.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.4.1 Define the feasibility study.

E.5.4.2 List the objectives of the feasibility study.

E.5.4.3 Relate why the feasibility study is conducted first in the design phase.

E.5.4.4 Give a practical example for each objective of the feasibility study.

CONTENT/CONCEPT

5. Reviewing the engineering design phases.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

5.5 Explain the use of the evaluation table in selecting the best alternative to develop in detail during the preliminary design phase.

5.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.5.5.1 Given the appropriate instruction and references students will review various evaluation tables and explain their importance and application in the design phase.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.5.5.1 Talk to a design engineer to reinforce the need for an evaluation table.

E.5.5.2 Compare various evaluation tables for content and layout.

E.5.5.3 Report on the extent that evaluation tables are used in industry.

COURSE: ENGINEERING PROJECTS

CONTENT/CONCEPT AREA:

5. Reviewing the engineering design phases.

EQUIPMENT AND MATERIALS

Overhead Projector

RESOURCES

Evaluation Table
Names of Engineers in Community

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science Publishers, Ann Arbor, MI.

Beakley, George C., Careers in Engineering and Technology, Macmillan Publishing Co., NY.

AUDIO-VISUAL MATERIALS

Transparency: The Engineering Design Process

Movie: "Industrial Design"
"Architectural Design"

Filmstrip: Product Design By Manufacturing Forum

CONTENT/CONCEPT AREA

6. USING THE DESIGN PROCESS AS A GROUP STUDY.

TASKS/COMPETENCIES

6.1 Participate in a brainstorming session dealing with a specific problem.

6.2 Discuss sources of information available to an engineer for problem solving.

6.3 Discuss the use of sketches, detail and assembly drawings in the design process.

6.4 Discuss the use of anthropometric tables.

6.5 Select appropriate materials and processes for design project.

6.6 Utilize tools, machines, and equipment safely.

6.7 List the objectives of an engineering test and safety factors.

6.8 Consider alternate design solutions to problem.

CONTENT/CONCEPT	COURSE
6. Using the design process as a group study.	ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

6.1 Participate in a brainstorming session dealing with a specific problem.

6.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.1.1 Given a specific problem the students will participate in a brainstorming activity giving ideas that relate to the topic.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.1.1 A record of all ideas should be made for future discussions.

E.6.1.2 Suggested ideas must not be criticized or evaluated.

E.6.1.3 Combine, modify, alter and add to ideas as they are suggested.

E.6.1.4 Suggest a large quantity of ideas for each problem discussed.

CONTENT/CONCEPT **COURSE**

6. Using the design process as a group study. ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

6.2 Discuss sources of information available to an engineer for problem solving.

6.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.2.1 Given the various sources of information available to the engineer for problem solving the students will participate in a discussion which will acquaint them with many of the sources available for their use.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.2.1 Talk to engineers (design) to acquire information sources.

E.6.2.2 List the sources available in a technical library.

E.6.2.3 Brainstorm with classmates on sources of information.

E.6.2.4 Write museums, research centers, and colleges for information.

CONTENT/CONCEPT **COURSE**

6. Using the design process as a group study. ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

6.3 Discuss the use of sketches, detail and assembly drawings in the design process.

6.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.3 Show how sketching is an important, quick means of expressing an idea by completing a simple assignment.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.3.1 Discuss with a draftsperson the need for good preliminary sketches and how they lead to detailed and assembly drawings.

E.6.3.2 List the components of a detailed drawing.

E.6.3.3 Discuss the importance of arranging the views of an assembly drawing.

E.6.3.4 Discuss good drawing practices and procedures.

E.6.3.5 Relate the capabilities and limitations of CAD systems.

E.6.3.6 Given written instructions will construct a small cube out of poster board then construct the same size cube using a drawing to see the importance of detailed drawings.

CONTENT/CONCEPT	COURSE
6. Using the design process as a group study.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
6.4 Discuss the use of anthropometric tables.	

6.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.4.1 Given a specific design project dealing with the human body the student will use the anthropometric tables for calculating specific proportions.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.4.1 Find the average length of arms, legs, head, body in the class.

E.6.4.2 Check average furniture sizes.

E.6.4.3 Check car interior sizes.

CONTENT/CONCEPT

6. Using the design process as a group study.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

6.5 Select appropriate materials and processes for design project.

CODE

6.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.5.1 Given a specific design problem the student will make calculations and decisions to select the proper material and process to be used in the solution of the problem. The calculations must justify the selection.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.5.1 List all the types of materials that would satisfy the design specifications.

E.6.5.2 Select the best material for the product after researching its qualities, availability, machinability, and cost.

E.6.5.3 Justify why a certain material was selected.

E.6.5.4 List the processes involved in making the designed project.

E.6.5.5 Develop a chart depicting the industrial related processes for the project.

CONTENT/CONCEPT	COURSE
6. Using the design process as a group study.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
6.6 Utilize tools, machines, and equipment safely.	

6.6

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.6.1 Given a specific design problem the student will determine the tools, machines, and equipment needed to complete his project safely according to accepted safety standards.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.6.1 Introduce tools, machines, and equipment available for student use.

E.6.6.2 Give appropriate instruction on the safe use of each.

E.6.6.3 Give appropriate safety tests.

CONTENT/CONCEPT	COURSE
6. Using the design process as a group study.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
6.7 List the objectives of an engineering test and safety factors.	6.7

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.7.1 Given a specific design problem the student will establish a list of written objectives for testing which establish a definite margin of safety.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.7.1 Determine and write objectives.

E.6.7.2 Discuss the properties of the materials to be tested.

E.6.7.3 Establish the method of testing.

E.6.7.4 Set up a system for testing the material safely.

CONTENT/CONCEPT	COURSE
6. Using the design process as a group study.	ENGINEERING PROJECTS

TASK/COMPETENCY **CODE**

6.8 Consider alternate design solutions to problem.

6.8

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.6.8.1 Given a specific design problem with exact parameters the student will formulate a workable alternate design solution for that problem.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.6.8.1 Study original design.

E.6.8.2 Brainstorm new ideas.

E.6.8.3 Prepare a model.

E.6.8.4 Analyze and evaluate the new idea.

E.6.8.5 Present your solution.

COURSE: ENGINEERING PROJECTS

CONTENT/CONCEPT AREA:

6. Using the design process as a group study.

EQUIPMENT AND MATERIALS

Chalk for recording brainstorm ideas
Poster board
Drawing equipment
Rules & tape measures
Safety tests on tools and machines
Equipment for testing materials to determine properties

RESOURCES

Textbooks
    (Materials book & properties.)
Samples of resource materials used by engineers.
Addresses for museums, research centers, and colleges/universities
Anthropometric Tables

AUDIO-VISUAL MATERIALS

Movies: "Sketching, Free-Hand Techniques"
        "Materials & Processes"
        "Reporting & Briefing"

Safety Posters to display and discuss

EP

CONTENT/CONCEPT AREA

7. COMMUNICATING THROUGH PROPOSALS, GRAPHICS, COMPUTERS, AND REPORTS.

TASKS/COMPETENCIES

7.1 Write letters, proposals, and technical reports.

7.2 Solve design problems with engineering graphics, descriptive geometry, and mathematical calculations to aid in the solution of the problem.

7.3 Present solutions using computer-aided design and drafting.

7.4 Program computer-aided machines and numerical controls.

7.5 Communicate with resource persons including engineers, technologists, and library personnel.

CONTENT/CONCEPT

COURSE

7. Communicating through proposals, graphics, computers, and reports.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

7.1 Write letters, proposals, and technical reports

7.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.1.1 Given the engineering project the student will write letters, proposals, and technical reports, which must communicate questions, ideas, and findings formed by the research team.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.1.1 Contact the business area teacher and have them show the format for writing a business letter.

E.7.1.2 To acquire information the students will write business letters.

E.7.1.3 The group will write a proposal justifying their procedure for solving a particular engineering project.

E.7.1.4 Upon completion of the project appropriate data will be formulated into a specific technical report.

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CONTENT/CONCEPT

COURSE

7. Communicating through proposals, graphics, computers, and reports.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

7.2 Solve design problems with engineering graphics, descriptive geometry, and mathematical calculations to aid in the solution of the problem.

7.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.2.1 Given a specific design problem the student will use engineering graphics, descriptive geometry, and mathematical calculations to aid in the solution of the problem.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.2.1 Use mathematical symbols to express a relationship between two or more variables.

E.7.2.2 Use engineering graphics to show the specific structure of the assigned area.

E.7.2.3 Apply descriptive geometry formulas and theories in the calculation of forces and surface areas that apply.

CONTENT/CONCEPT	COURSE
7. Communicating through proposals, graphics, computers, and reports.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
7.3 Present solutions using computer-aided design and drafting.	7.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.3.1 Given the engineering project the student will use the appropriate computer software program that will enable the drawing of the project or the computation of forces within the project.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.3.1 Use a CAD system for drafting.

7.3.2 Apply appropriate computer software for problem solving.

CONTENT/CONCEPT

COURSE

7. Communicating through proposals, graphics, computers, and reports.

ENGINEERING PROJECTS

TASK/COMPETENCY

CODE

7.4 Program computer-aided machines and numerical controls.

7.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.4.1 Given a problem the student will be able to program a computer-aided machine to perform to within .010" and establish the X,Y, and Z points for numerical control.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.4.1 Program a CAM.

E.7.4.2 Find X,Y,Z quadrants.

E.7.4.3 Label the various points with letters and establish distances form the origin point on X,Y, and Z quadrants.

CONTENT/CONCEPT	COURSE
7. Communicating through proposals, graphics, computers, and reports.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
7.5 Communicate with resource persons including engineers, technologists, and library personnel.	7.5

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.7.5.1 Given the engineering problem the students will communicate with resource persons including engineers, technologists, and library personnel for the purpose of gathering information that will aid in solving the proposed problem.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.7.5.1 Interview an engineer.

E.7.5.2 Interview a technologist.

E.7.5.3 Interview library personnel.

E.7.5.4 Write letters, conduct interviews and make phone calls.

COURSE: ENGINEERING PROJECTS

CONTENT/CONCEPT AREA:

7. Communicating through proposals, graphics, computers, and reports.

EQUIPMENT AND MATERIALS

Handouts and sample letters by teacher
Sample proposal by other students
Format guidelines for proposal
Computer with Computer-Aided Design and Drafting software
Numerical control simulator, model, or software

RESOURCES

Names of business and English teachers who could assist students in writing.
Names of Engineers, technologists, and technicians in community.

Books: Technical writing books from library.
Mathematics
Engineering graphics
Descriptive Geometry by David Alkazin

AUDIO-VISUAL MATERIALS

Movie: "Reporting & Briefing" by Centron Films, Inc.

Transpariencies: Sample letter requesting information.
Format for proposal.

CONTENT/CONCEPT AREA

8. BRIEFING OTHERS ON RESULTS OF ENGINEERING.

TASKS/COMPETENCIES

8.1 Present an oral report on problem-solving activities.

8.2 Pre-register for competitive events.

8.3 Prepare a written technical report on problem-solving activities.

8.4 Construct a display of activities to use ina public location.

CONTENT/CONCEPT	COURSE
8. Briefing others on results of engineering.	ENGINEERING PROEJCTS

TASK/COMPETENCY	CODE
8.1 Present an oral report on problem-solving activities.	
	8.1

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.1.1 Upon completion of a problem, the student will organize and present an oral report on the activities of the problem solved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.1.1 Request assistance from math, science and english teachers to assist students on problem-solving activity.

E.8.1.2 Appoint an advisory committee to help with resources.

E.8.1.3 Organize a seminar for students to give oral reports on their problem-solving activity to advisory committee, other teachers, and other students--prepare invitations and announcement flyers.

E.8.1.4 Display student work before and after seminar.

E.8.1.5 Give recognition to consultants for assistance and attendance.

CONTENT/CONCEPT

8. Briefing others on results of engineering.

COURSE

ENGINEERING PROJECTS

TASK/COMPETENCY

8.2 Pre-register for competitive events.

CODE

8.2

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.2.1 Given the rules and criteria for local, regional, state and national competitive events, students will select events related to engineering problems solved and pre-register for appropriate competition using the criteria and rules for entry as the standards.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.2.1 Review the rules and criteria for competitive events of appropriate engineering problems solved.

E.8.2.2 Complete pre-registration forms for appropriate competitive events.

E.8.2.3 Prepare materials and problem solved for entry according to the standards of the event.

CONTENT/CONCEPT	COURSE
8. Briefing others on results of engineering.	ENGINEERING PROJECTS

TASK/COMPETENCY	CODE
8.3 Prepare a written technical report on problem-solving activities.	

8.3

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.3.1 Upon completion of a problem the student will organize and present a written report on the activities of the problem solved.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.3.1 Request assistance from math, science, and english teachers to assist students on problem-solving activity.

E.8.3.2 Appoint an advisory committee to help with problem-solving activity.

E.8.3.3 Present the written technical report to the advisory committee for critique and/or competition.

E.8.3.4 Display problem solved with written technical report.

E.8.3.5 Give recognition to consultants for assitance and attendance.

CONTENT/CONCEPT	COURSE
8. Briefing others on results of engineering.	ENGINEERING PROJECTS

TASK/COMPETENCY CODE

8.4 Construct a display of activities to use in a public location.

8.4

PERFORMANCE OBJECTIVE WITH CRITERION-REFERENCED MEASURE

P.8.4.1 Given materials for exhibit, construct a display of activities of problems solved to use in public locations to communicate the program.

ENABLING OBJECTIVES WITH TECHNOLOGY LEARNING ACTIVITIES

E.8.4.1 Organize, design, select materials and construct a display.

E.8.4.2 Involve student in selecting a site for display of problem-solving projects and design activities, eg. mall, school board office, bank buildings, etc.

E.8.4.3 Obtain permission for date and location from proper authorities.

E.8.4.4 Write news release for local papers to announce the display and list all students and their projects.

E.8.4.5 Prepare display for competition in regional, state, and national events according to the criteria for the event.

CONTENT/CONCEPT AREA:

8. Briefing others on results of engineering.

EQUIPMENT AND MATERIALS

RESOURCES

Rules and Criteria for Virginia and National Contests 1987.
Identifies permanent rules for Regional Fairs and the Virginia Spring Festival and National Conference.
Order from: Technology Education Service, VA Dept. of Education,
P.O. Box 6Q, Richmond, VA 23216

Competitive Events Guidelines 1985.
Order from: AIASA National Office
1908 Association Drive, Reston, VA 22091
Cost: $3

AUDIO-VISUAL MATERIALS

Movie: Reporting and Briefing, Centron Films, Inc.

EP

BIBLIOGRAPHY

Alkazin, D. M., Descriptive Geometry Workbook, Prakken Publications, Inc. 416 Longshore Dr. P.O. Box 8623, Ann Arbor, MI 48107, 1985.

Bailey, Robert L., Disciplined Creativity for Engineers, Ann Harbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180, 1978.

Bame, E. Allen & Cummings, Paul, Exploring Technology, Davis Publications, Incorporated, 1980.

Beakley, George C. & Leach, H.W., Engineering: An Introduction to a Creative Profession, Fourth Edition, Macmillan Publishing Company, NY 1984

Blotter, Thomas P., Introduction to Engineering, John Wiley & Sons, 1 Wiley Drive, Somerset, NJ 08873, 1981.

Jacobs, James A. & Kilduff, Thomas F., Engineering Materials Technology, Prentice Hall, Inc., Inglewood Cliff, NJ 07632,1985.

Kemper, John Dustin, Introduction to the Engineering Profession, Holt, Rinehart and Winston, 1985.

Krick, Edward V., An Introduction to Engineering--Concepts, Methods and Issues, John Wiley, 1976.

Morris, George E., Engineering--A Decision-Making Process, Houghton Mifflin, 1977.

Red, W. Edward, Careers in Engineering and Technology, Brooks/Cole Division, Wadsworth, Inc., 1983.

Red, W. Edward & Mooring, Benjamin, Engineering - Fundamentals of Problem solving, Brooks/Cole Division, Wadsworth, Inc., 1983.

Schwaller, Anthony E., Energy Technology: Sources of Power, Davis Publications, Inc., 1980.

Strakosk, George, Vertical Transportation Elevators and Escalators, John Wiley and Sons Inc., 605 3rd Ave., New York, NY 10158.

Unified Technical Concepts-Physics for Technicians, Second Edition, The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710, 1984.

REF:1
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APPENDICES

A. Information and Resources
   I. General Reference Books
   II. Magazines/Periodicals Related to Engineering and Technology
   III. Booklets and Catalogs for Problem Solving Activities
   IV. Computer Software, Interfacing, and Applications
   V. Films and Video Tape Recordings
   VI. Math and Science Resources
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C. Career and Educational Information
   I. Career Slide Script
   II. Questions for Potential Engineers
   III. Careers in Technology
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   V. Engineering Schools in Virginia
   IV. Community Colleges in Virginia
D. Library Book List (Suggestions for librarian to order)
E. Engineering Projects and Case Studies
F. Formulas and Charts for Student Reference
G. Glossary of Engineering Terms
H. Laboratory Facilities and Equipment List
I. Instructional Materials
   I. Transparency Masters
   II. Student Handouts
   III. Sample Group Projects
J. JETS and Technology Student Associations
K. Evaluation Techniques
   I. Tests
   II. Performance/Problem Solving Exams

APPENDIX A

INFORMATION AND RESOURCES

I. General Reference Books

Contemporary Approaches to Teaching Technology. Order from: American Council of Industrial Arts Supervisors, 2407 LaPorte Ave., Ft. Collins. CO 80521 1983.

Technical Communications. ISBN 1-55502-164-6. Technical Core Course available from The Center for Occupational Research and Development, 601C Lake Air Dr., Waco, TX 76710.

Order the following books published by VGM Career Horizons
from Goodheart-Willcox. 123 W. Taft Dr., South Holland, IL 60473
Opportunities in Chemical Engineering
Opportunities in Civil Engineering
Opportunities in Electronic and Electrical Engineering
Opportunities in Engineering Technology
Opportunities in Mechanical Engineering

Alkazin, D. M., Descriptive Geometry Workbook. Prakken Publications, Inc., 416 Longshore Dr., P.O. Box 8623, Ann Arbor. MI 48107, 1985.

Bame, E. Allen & Cummings, Paul. Exploring Technology. Davis Publicationtions Inc., 1980.

Betts, John E., Physics for Technology. Prentice Hall, Reston, VA, 1981.

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Kivenson, Gilbert, The Art and Science of Inventing. 2nd Ed., New York: Van Nostrand Reinhold Co., Inc. 1982.

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McCrory, David and George R. Maughan, Resources in Technology. Davis Publications, Inc., Worcester, MA 01608.

Meriam, J. L. Engineering Mechanics Statics and Dynamics. John Wiley & Sons, 1978.

Morris, George E. Engineering--A Decision-Making Process. Houghton Mifflin, 1977.

Naisbitt. John. MegaTrends. Warner Books, 1984. Order from: Local Bookstore. Borrow from Library.

Pellegrino, Charles R., Stoff, Joshua. Chariots for Apollo. The making of the lunar module. Atheneum. New York. 1985.

Red. W. Edward. Careers in Engineering and Technology. Brooks/Cole Division. Wadsworth, Inc., Belmont, CA 94002, 1983.

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Schwaller, Anthony E. Energy Technology: Sources of Power. Davis Publications Inc., 1980.

Strakosk, George. Vertical Transportation Elevators and Escalators. John Wiley & Sons, Inc., 605 3rd Ave., New York, NY 10158.

Thode, Bradley R. Material Processing. Delmar Publishers, Albany, NY, 12212, 1982.

Wulffson, Don L., The Invention of Ordinary Things. New York: Lothrop, Lee, and Shepard Books, 1981.

II. Magazines/Periodicals Related to Engineering and Technology

Aerospace, Aerospace Industries Association, 1725 DeSales St., N.W., Washington DC 20036

Air & Space, Air & Space Smithsonian, Washington, DC 20560

CAD Educator Bulletin, Autodesk Inc., 2320 Marinship, Sausalito, CA 94965.

CADalyst, CADalyst Publications, 282-810 W. Broadway, Vancouver, B. C. Canada V5Z 4C9.

Final Draft, Quarterly Newsletter for AutoCAD Users.

High Technology, Technology Publishing Co., 38 Commercial Wharf, Boston, MA 02110.

L5 News, L5 Society, 1060 E. Elm, Tucson, AZ 85719.

The Lamp, Exxon Corp., 1251 Ave. of the Americas, New York, NY 10020-1198.

Manufacturing Forum, Dept. of Industrial Education and Technology, Ball State University, Muncie, Indiana 47306.

NASA Report to Educators, c/o Educational Programs Office, NASA Hdqs., Washington DC 20546.

NASA Tech Briefs, 41 E. 42nd St., Suite 921, New York, NY 10017.

Popular Science, Subscription Department, Boulder, Colorado 80302.

Rhino User Robots Report, Rhino Robots, Inc., 3402 N. Mattis, P.O. Box 4010, Champaign, IL 61820.

SSI Newsletter, Space Studies Institute, 285 Rosedale Rd., P. O. Box 82, Princeton, NJ 08540.

Science 87 (each year), Science 87 Subscription Dept., P.O. Box 10790, Des Moines, IA 50340.

The Technology Teacher A Journal of the International Technology Education Association. Journal comes with professional membership at $40.00, from ITEA, 1914 Association Dr. Reston, VA 22091.

III. Booklets and Catalogs for Problem Solving Activities

After High School, What?, (Brochure) National Council for Guidance, c/o JETS, 345 E. 47th St., New York, NY 10017.

AIASA Competitive Events Guidelines, AIASA National Office, 1908 Association Dr., Reston, VA 22091.

AIASA Member Guide See Address Above, Cost: $25 (Pkg. of 30)

AIASA Chapter Handbook See Address Above, Cost: $4

Parliamentary Procedures at a Glance - Booklet by Garfield O. Jones Hawthorn Books, Inc. 260 Madison Ave., New York, NY 10016

Billington, David P., Robert Marllart's Bridges: The Art of Engineering. Princeton, N.J.: Princeton Univ. Press, 1979.

Fuller, R. Buckminster, Inventions: The Complete Patented Works of R. Buckminster Fuller. New York: St. Martins Press, 1983.

Hafford, Wm. E., and McWhorter, Eugene W. Understanding Solid State Electronics (for anyone). Texas Instruments, P.O. Box 225012, MS54, Dallas, TX 75265.

Harrisberger, Lee, Engineersmanship. Monterey, CA: Brooks/Cole Pub. Co., 1982.

Innovation, E. I. du Pont de Nemours, Public Relations, Chestnut Run, Wilmington, Delaware 1983. (free)

Micklus, Samuel C., Odyssey of the Mind: Problems to Develop Creativity. Glassboro, N.J.: Creative Competitions, Inc., 1984.

Micklus, Samuel C. & Gourley, T. J., Problems! Problems! Problems!. Glassboro, N.J.: Creative Competitions, Inc., 1983.

NASA. Aerospace Engineers: We're Tomorrow-Minded People also Aerospace Technicians and Aerospace Scientists. Order each from Educational Programs Officer at the NASA Center serving your state or NASA Administration, Washington, DC

Shlesinger, Jr., B. Edward. The Art of Successful Inventions. Kelly Wafner Assoc., Inc., Washington DC 1973. Library of Congress Catalog Card #74-81268.

Tidewater Technology Associates, "Space Frames and Geodesic Domes," The Technology Teacher. April 1984. p. 23.

Warring, R. H., Robots & Robotology. Blue Ridge Summit, PA: Tab Books, 1984.

Weiss, Malcolm E., Far Out Factories Manufacturing in Space. New York: Lodestar Books, 1984.

Bracing Wood Trusses from local building materials supplier.

Experiments: Properties of Gas and Heat Energy. Order No. N00085. Gas Centered Projects for Science Fairs. Order No. N00475. Educational Programs. American Gas Assoc., Dept. Pro., 1515 Wilson Blvd., Arlington, VA 22209.

Research/Penn State. Published quarterly by Penn State University, 114 Kern Bldg., University Park, PA 16802

The Engineering/High-Tech Student's Handbook: Preparing for Careers of the Future. David R. Reyes-Guerra and Alan M. Fischer with the Editors of Peterson's Guides in local library.

Technology Activities. Thomas A. Hughes, Jr., Editor. The best project ideas from The Technology Teacher. Available from International Technology Education Association, Reston, VA 22091.

Working With the Atom: Careers for You. Atomic Industrial Forum, Inc., 7101 Wisconsin Ave., Bethesda, MD 20814-4891.

The World of Airplanes. Order from Midwest Products Co., Inc., Hobart, Indiana 46342.

The World of Work. Career Education booklets on Engineer, Technician, etc. Order free set from: Marian Wallace. Educational Communications, General Electric Company, Fairfield. CT 06431.

The Young Engineer--An Annotated Bibliography 1890-1978. Gillespie, P.E. Editor. Accreditation Bd for Eng. & Tech, NY 10017.

Your Engineering Career Kit. A complete set of development literature for young engineers. Accreditation Bd for Eng. & Tech, NY 10017.

Order materials below by writing for order form from: National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State Univ. of New York at Stony Brook, Stony Brook, NY 11794.

Earthquakes
Flywheels
Problems in Search of A Calculator

IV. Computer Software, Interfacing, and Applications

Computer Applications in Technology. Barnes & Windham. Order from: Ext. Instruction & Materials Center, The Univ. of Texas, Austin, TX

Computer Programs for Industrial Arts/Technology education. Sarapin & Post. Order from: Goodheart-Willcox, 123 W. Taft Dr., So. Holland, IL 60473.

The Factory: Strategies in Problem Solving. Sunburst Communications, Box 40, 39 Washington Ave., Pleasantville, NY 10570.

Print Shop. Broderbund Software, Apple II or IBM. Purchase from local dealer, $49.95.

Rocky's Boot (a simulation game that teachers digital logic systems) Order from dealer or software catolog.

Scientific Measurements. MP 040 D-A, Apple II, IIe Disk. Program offers examples and exercises in reading three instruments: Graduate Cylinder, Metric Ruler, and Triple Beam Balance. Micro Learningware, Hwy 66 S., Box 307, Mankato, MN 56002-0307.

The Scientific Method. MP 049 D-A, Apple II, IIe Disk. Program leads student through experiment simulations on Observation, Generalization, Measurement, and Verification. Micro Learningware, Hwy 66 S., Box 307, Mankato, MN 56002-0307.

Simple Machines. MP 051 D-A, Apple II, IIe Disk. Program covers six machines: Lever, Pulley, Wheel and axle, Inclined plane, Wedge, and Screw. Micro Learningware, Hwy 66 S., Box 307, Mankato, MN 56002-0307.

Three Mile Island (a simulation game concerning power plant control systems) Obtain from any dealer or catolog.

Culpepper, Fred, Mathematics in Electricity, Norfolk, VA: Old Dominion University, Technology Education Program Area,1986.

Moth, Irwin, Bits and Pieces: Understanding and Building Computer Devices. New York: Charles Scribner's Sons, 1984.

Tatchell, Judy & Cutter, Nick, Practical Things to Do With a Microcomputer. Tulsa, OK: EDC Publishing, 1983.

Tokheim, Roger L. Electronics Microcomputer Circuits. 146 Practical Projects, $9.95. McGraw-Hill Book Co., Princeton Rd., Highstown, NJ 08520.

V. Films and Video Tape Recordings

Using Materials(548-6314)
Combining the Principles(548-6331)
Process of Engineering Production(548-6332-7)

Order above films from: Films, Inc., Preview Library, 1144 Wilmette Ave., Wilmette, IL 60091.

Art of Learning Grades 9-12, Six 20-min. programs for high school students who are preparing to go to college. AIT, P.O. Box A, Bloomington, IN 47402

Audiovisual Instructional Materials (Catalog of state films in your school library.) Films and video tapes are listed in the Technology Education (industrial arts) section.

CAD/CAM Technology. Filmstrip series with 6 cassetts. Order from Library Filmstrip Center, 608 E. Locust St., Bloomington, IL 61701.

The Challenge of Manufacturing Sponsor: Society of Manufacturing Engineers. Distributed by Modern Talking Picture Service, Inc., or Call Technology Education Service, VA Dept. of Education, Richmond.

It Couldn't Be Done Rent this film for $27 from Univ. of Illinois Film Library, 1325 S. Oak St., Champaign, IL 61820. Call 1-800-367-3456.

Leadership and Productivity (innovations in manufacturing, CAD & CAM, etc.) 16mm, 25 min. SME, Education Dept., One SME Drive, P.O. Box 930, Dearborn, MI 48121. 1980.

Monument to a Dream 16mm movie by U. S. Steel - (AVD get more info)

NASA Film Catalog Teachers may also send blank tapes to NASA for duplicating almost all movies. Request film catalog and video list from Educational Programs Office, NASA Langley Research Center, Mail Stop 145B, Technical Library, Tampton, VA 23665.

Phillips Search for Solutions. A series of 9 movies or videos on problem solving as related to almost any area of science and technology. Request film and teaching guide from: Karol Media, 22 Riverview Dr., Wayne, NJ 07470.

Product Design Filmstrip from Manufacturing Forum, Ball State Univ., Muncie, IN 47306.

Robotics Filmstrip Series with titles about industry, subsystems, applications, and human factors. Order 6 filmstrips and cassettes for $210 from Library Filmstrip Center, 608 E. Locust St., Bloomington, IL 61701.

Robots VI: Tomorrow's Technology on Display color videocassette, 47 min. SME One SME Dr., P. O. Box 930, Dearborn, MI 48121, 1982.

The Science of Steelmaking Free Filmstrip from American Iron and Steel Inst., 1000 16th St., N.W., Washington, DC 20036.

Space (Related AV & Posters) Catalog. Aerospace Resources International, P. O. Box 5872, Friendship Station, Washington, DC 20016-1472.

VI. Math and Science Resources (and Books from each Course in School)

Applied Algebra and Geometry Modules. (These practical modules or booklets provide students with practice.)

Problem Formulation in Algebra Mixtures: Algebra and Chemistry

Offshore Limits with Geometry

Using Geometric Logic

Mathematics Resource Guide

Problems in Search of a Calculator

Order the above by writing for order form from: National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State Univ. of New York at Stony Brook, Stony Brook, NY, 11794

Betts, John E. Physics for Technology. Reston Publishing Co., Inc., Prentice-Hall, Reston, VA. 2nd Edition.

Demchik, Michael J. "How Science Activities Can Make Mathematical Conceptualizations a Reality," Science Activities. Feb/March 1985.

Fundamentals of Spatial Relationship, Earle, James H. Addison-Wesley, Reading, PA 19603, 1973.

Gehring, Gary B., Making Vector Analysis Easier. School Shop. May 1983, pp. 26-27.

How Can I Get In Touch With Project Sci-Math?. Helps students apply mathematics to science and other practical ways. Modules 1 & 2 also have Teacher's Guides. Write for details to Sci-Math Curriculum, Area Cooperative Educ. Services, 295 Mill Rd., North Haven, CT 06473.

Introduction to Graph Theory with Applications. National Science Foundation. 1983.

Mathematics in Electricity Solves math problems with electrical circuits Order from Technology Education Service, VA Dept of Education.

Math/Science/Technology Projects for the Technology Teacher (1985). International Technology Education Assoc., 1914 Assoc. Dr., Reston, VA 22091.

Mathematics for Technical and Vocational Studies. Boyce, et. al. Shop examples, trigonometry, problems in Geometry Construction, Protractor. John Wiley & Sons, 1982.

Popwski, John D. Mathematical Tools for Machine Technology. Breton Publishing Co., North Scituate, Massachusetts, 1982.

Problem Solving in Algebra. Encyclopedia Britannica, 425 N. Michigan Ave., Chicago, IL 60611, 1983.

The Problem Solvers supplemental books for math and science, sold in college bookstores or order from Research and Education Asociates, 505 Eight St., NY, NY 10018.

Schaum's Outline Series supplemental books for math and science, sold in college bookstores or obtain from Schaum's (no address yet)

Sci-Math: Module 1 and 2. Addison-Wesley Publishing Co., Innovative Div., Sand Hill Rd., Menlo Park, CA 94025.

Science Activities. Source of experiments, explorations, and projects. Subscription $25. Heldref Publications, Dept. 13-A, 4000 Albemarle St., NW, Washington, DC 20016.

A Sourcebook of Application of School Math. Fuel Gauges, Digital Clocks, Sports, House Heating. Prepared by a joint committee of the Mathematical Association of America and N.C. of Teaching Math, 1980.

Trigonometry in Action. Ferguson & Ferguson. J. Weston Walch, Portland, ME 04104, 1981.

Calculus Grades 12-College, Twenty-one 30-min. video programs for a complete course. AIT, P.O. Box A, Bloomington, IN 47402-0120.

Math Topics Grades 10-12, Ten 20-min. programs. Provides a bridge between pencil and paper math lessons and the actual use and applications of mathematics. AIT, P.O. Box A, Bloomington, IN 47402-0120.

Unified Technical Concepts for Physics ($24 ISBN 1-55502-161-1) with Applications (lab manual), Vol. I & II ($18 ea ISBN 1-55502-162-X). Order from The Center for Occupational Research and Development, 601C Lake Air Dr., Waco, TX 76710.

VII. Speakers, Tours, and Resource Persons

Bath County Pumped Storage Project. VEPCO, P.O. Box 26666, Richmond, VA 23261.

Bristol Steel & Iron Works, Inc., 300 Piedmont St., P. O. Box 471, Bristol, VA 24201.

C & P Telephone, 703 E. Grace St., Richmond, VA 23219.

Directory of SME Student Chapters/Units and their Faculty Advisors&
Directory of SME Chapters for professionals
Above information from SME Member Relations, One SME Dr., P.O. Box 930 Dearborn, MI 48121.

Engineering students at Virginia Tech may speak to classes in high schools near their homes. Call Dr. Leo Padis at Virginia Tech (703-961-6642) to arrange speaker.

National Technical Information Service, U. S. Department of Commerce, Operations Division, Springfield, VA 22151.

National Aeronautics & Space Administration, Langley Research Center, Educational Programs Office, Mail Stop 154, Hampton, VA 23365.

National Bureau of Standards, U. S. Department of Commerce, Route 270, Gaithersburg, MD 20234.

Teacher Education faculty or students at George Mason Univ., Norfolk State Univ., Old Dominion Univ., Virginia State Univ., and Virginia Tech may speak to classes in region of state. Call Department of Tech Education at university nearest your school to arrange speaker.

Virginia Department of Highways and Transportation offices are located all over the state. Contact the office near your school to ask if an engineer might be able to speak to the engineering class at your school.

Virginia VIEW Career Hotline - 1-800-542-587 (missing digit)

U. S. Patent Office, Washington, DC 20231

APPENDIX B

ADVISORY COMMITTEE

Advisory Committees are used by many agencies and schools to develop linkages with the community. An Introduction to Engineering advisory committee can help to:

1. Meet industrial and community leaders who want to help teachers and young people.
2. Inform more people of the curriculum of technology education.
3. Obtain support and assistance for educational programs such as speakers, supplies, equipment, and consultation with students on problem-solving projects/ideas.

An Advisory Committee could meet at the school in the afternoon. If more than one hour is needed, the meeting could begin at 7:00 or 7:30 p.m.

To organize your Advisory Committee, the following steps are suggested:

Step 1. Discuss the need with your principal and/or local supervisor/director.

Step 2. Make a list of engineers and other people in the region whom you know or have heard about. Watch the newspapers for people involved in community and schools, or maybe a parent or friend of a friend. (See categories of people to list.)

Step 3. Visit or call each person to discuss how you would like them to sit down at the school and help you with the Introduction to Engineering course.

Step 4. Send out notice of the first meeting and location. Your supervisor or teacher educator could help send out notice.

Step 5. Prepare agenda and handouts for people as they arrive at meeting. Introduce people to each other.

Step 6. Share information and ask for suggestions and help.

Step 7. Teacher educator could help take notes at meeting.

Step 8. Have students talk about their activities, projects, problems, and progress.

Step 9. Allow committee to comment, commend, and contribute to students and program.

Step 10. Thank people for coming and set tentative date to meet or see them again.

ADV COMM. E
PE 3

IN-SCHOOL CONSULTANTS COMMITTEE

This committee is composed of other teachers willing to assist Introduction to Engineering students with interdisciplinary problem solving on engineering projects.

Mathematics Teacher
Science/Physics Teacher
Librarian
Social Studies Teacher
Guidance Counselor

ESTABLISHING THE SCHOOL CONSULTANTS COMMITTEE

Step 1. School Principal Approval

Step 2. Purpose and Function

Step 3. Selection of Members

Step 4. Appointment of Members/Consultants

Step 5. Organizing and Managing the First Meeting

Step 6. Establishing Consultants Role

Step 7. Plan a program of work or a one or two-year plan involving the committee on a continuous basis.

ADVISORY COMMITTEES

To the Members of the Committees:

We have invited you to help us motivate students to pursue careers in technology and engineering. You can help by meeting with the technology education teacher and others listed below who are on the Community Advisory Committee.

Engineers - ____________________
Technician - ____________________
Community College Programs - ____________________
Teacher Education Faculty (may serve as secretary) - ____________________
Superintendent's Office - ____________________
PTA or PTSO - ____________________
Associations (such as: SME, ASTME) - ____________________
Service Branches - ____________________
Others to Consider
  a. Education Reports for Paper - ____________________
  b. Retired Business & Industry Leaders - ____________________

To the Members of the School Consulting Team:

Many teachers in the school will be able to help motivate students, reinforce math and science through technology activities, projects, or problems. Some of these students will pursue technical careers, while others may choose engineering. School personnel listed below will be of great help as they consult, advise, and counsel industrial arts students.

School Principal - ____________________
Science Teacher - ____________________
Algebra Teacher - ____________________
Geometry Teacher - ____________________
Guidance Counselor - ____________________
English Teacher - ____________________
Other Industrial Arts Teachers - ____________________ ____________________

Meeting Suggestions:

The above Committees could meet often but, if they met twice, it would be great.

First Meeting - during September or October, after students have started an activity.

Final Meeting - during May or June to observe Final Reporting Seminar when students give results and demonstrate project, model, or product.

APPENDIX C

CAREER AND EDUCATIONAL INFORMATION

I. Career Slide Script
II. Important Questions for Potential Engineers
III. Today's Engineering Team (Reprint)
IV. Engineering Colleges in Virginia
V. Community Colleges in Virginia
VI. Other

A SLIDE/TAPE
PROGRAM

ENGINEERING:
AN INTRODUCTION
TO THE FIELD
AND ITS
CAREERS

by

DR. JAMES A. JACOBS
SCHOOL OF TECHNOLOGY
NORFOLK STATE UNIVERSITY

for

THE TECHNOLOGY EDUCATION SERVICE

DEPARTMENT OF EDUCATION

COMMONWEALTH OF VIRGINIA

1985

This 35-minute slide/tape program serves to introduce the field of engineering. It examines engineering as an activity, as a field of study, and as a profession. Using the "engineering team" for reference, careers in engineering and how to prepare for those careers are explained in relation to activities in the field. Finally, the engineering method is seen through research, development, design, and manufacturing plus other aspects involving "problem solving." Examples of engineering products and systems from many engineering specialties provide the viewer with a proper perspective of the diversity of the field.

This program is designed to present 3 segments: 1) an introduction and definition, 2) the engineering team and careers in engineering, and 3) the engineering method. More than one class session should be planned for studying this program, since time for discussion is best provided after each segment. By previewing the program, the instructor can provide a proper introduction with major points for students to look for in the program. These points then serve the review period.

The following objectives might be presented to the student prior to the program as major areas to focus their attention.

objectives:

As a result of viewing this program, the student should be able to do the following:

1. Match the following terms to their definitions:

    a. engineer
    b. technician
    c. crafts person
    d. scientist
    e. technologist
    f. standards
    g. codes
    h. modeling
    i. high tech
    j. systems
    k. product
    l. AAS
    m. 2 plus 2 program

2. List four phases of the "engineering method."

3. List five engineering specialties and name a product, system, or procedure generated by each specialty.

4. Describe the preparation normally required to enter career positions on the engineering team.

5. Evaluate the field of engineering in terms of personal interests and aptitude to determine what type of position may be desirable to begin career preparation.

6. Express a personal value regarding concern for society and the environment, then cite an example of how engineering may help to address the concern.

7. Determine which products or systems should be considered high or advanced technology and those that are products of standard engineering.

8. Show an appreciation for the importance of standards and codes for engineering by describing two standards or codes that are indispensable to a modern technological society.

9. Cite at least four governmental agencies or technical societies that develop standards for engineering, and list a product, system, or procedure related to each.

10. Develop a positive attitude toward the field of engineering and seek further information about the topics shown in the program.

ENGINEERING: AN INTRODUCTION TO THE FIELD AND ITS CAREERS

by
Dr. James A. Jacobs

(35 minutes)

FOCUS SLIDE Engineering: An Introduction To The Field and Its Careers

slide #	narrative
1	(no narrative -- begin music)
2	We see the results of engineering all around us in all phases of our life and society. Computer aided high technology yields a variety of new products, including new communication devices . . .
3	that employ optical fibers . . .
4	and laser light.
5	Increases in automated manufacturing aided by robotics are changing the work place . . .
6	by requiring new skills and knowledge to replace old jobs.
7	Historically, engineering has provided innovative technology to aid society. Early means of power that employed windmills is still in use today with . . .
8	new engineering twists . . .
9	Nuclear energy seems to hold potential as a nearly unlimited energy source, but we still must deal with many challenges.
10	Fossil fuel in the form of coal is still abundant in the United States . . .
11	but we must employ the best that science can offer to ensure that coal does not pollute our delicate environment.
12	The quest for energy to satisfy humanity . . .
13	for ages to come, will be a function of engineering.
14	We rely on Engineering for our shelter . . .
15	employing such engineering specialist as architectural engineering, civil engineering . . .

16 structural engineering, and mechanical engineering.

17 Historical monuments are products of engineering . . .

18 as are the capitals of government.

19 Engineering also supports agriculture . . .

20 with many products and systems . . .

21 that help feed the world.

22 We rely on engineering to protect the environment . . .

23 and bioengineering provides the support to medicine through development of materials and instruments that range from dental and surgical equipment . . .

24 or to devices, such as pace-makers, to implant into the body which aid diseased organs . . .

25 or joint replacements . . .

26 such as this total hip replacement joint made of metal alloys.

27 Electrical and electronic engineers design circuits and components that are integrated into products . . .

28 that are designed by mechanical engineers and produced with systems designed by industrial and manufacturing engineers.

29 The history of our world includes transportation.

30 Early aircraft seem crude . . .

31 compared to modern aircraft . . .

32 designed by aeronautical . . .

33 and aerospace engineers.

34 Road systems composed of many elements including drains and sewers bridges . . .

35 signs, lighting . . .

36 and tunnels . . .

37 reflect civil engineering.

38 Waterways provide another mode of transport.

39 Many types of engineers work in this field, including marine engineers.

40 Another system is manufacturing and today the emphasis is on automated manufacturing.

41 New materials and processes must be constantly developed . . .

42 if this nation wishes to remain competitive in manufacturing.

43 What is engineering? What are the career opportunities in engineering?

44 The term "engineering" has a number of meanings. It describes a field of study, including college programs to earn degrees in engineering and engineering technology. It describes a very large field of work with numerous specialties within it such as mechanical engineering, civil engineering, materials engineering, bioengineering, and systems engineering.

45 As an activity, engineering has many meanings but all focus on problem solving.

46 The Accreditation Board of Engineering and Technology defines engineering as ". . . the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, and with concern for the environment and society the materials and forces of nature for the benefit of mankind."

47 Engineering has a rich history. Products range from Cape Henry Lighthouse, the first lighthouse authorized by the U. S. Congress and erected in 1791 . . .

48 to the modern Cape Henry Lighthouse . . .

49 which is a fully automated lighthouse.

50 The frigate U.S.S. Constellation, launched in 1797, represents early American marine engineering . . .

51 while modern naval vessels reflect engineering with high technology.

52 Modern medicine also relies on high tech and standard engineering practices that involve using materials and computer technology that relieve suffering and prolong and improve the quality of life.

53 As we saw earlier, engineering results not only in products--much engineering activity results in systems.

These systems include road systems . . .

54 computer systems . . .

55 and many types of communications systems such as telephone, television, and microwave systems.

56 Another very important activity in engineering is the development of standards and codes. Standards and codes serve as guides to ensure safety and compatibility of products, systems, and procedures.

For example, automobile tires are made to standards so that they will fit the wheels for which they are designed. And electricity generated by the power company is a standard voltage to safely operate your products.

57 Standards are developed by hundreds of agencies of both government and engineering societies. The National Bureau of Standards of the U. S. Commerce Department develops standards . . .

58 and conducts testing to ensure that the standards are suitable.

59 These standards cover a wide range of fields in science and engineering, including time . . .

60 engineering materials . . .

61 chemicals . . .

62 fire safety . . .

63 and weights and measures plus many, many more.

64 NASA works with the U. S. Defense Department and private industry to develop standards for aeronautics . . .

65 including studies of aerodynamics . . .

66 wind tunnel testing to evaluate air turbulence . . .

67 and noise abatement.

68 Specifications for engineering activities are developed from standards by other agencies, such as used by the American Bureau of Shipping and the U. S. Coast Guard . . .

69 which in turn ship builders follow.

70 Local building codes are another form of standards that cover construction of homes, schools, and all types of structures.

71 Among the long list of technical societies involved in developing codes and standards, are the American Society for Testing and Materials, American Society of Civil Engineers, American Society of Safety Engineers, Institute of Electrical & Electronics Engineers, Inc., Society of Automotive Engineers, and Society of Plastics Engineers, Inc., to name but a few.

Produced by the Technology Education Service Staff
Department of Education, Commonwealth of Virginia

72 Developed by Dr. James A. Jacobs, School of Technology
Norfolk State University

Narrated by Mr. Raymond T. Jones, Coordinator
Public Information, Chesapeake School Division

Technical assistance by Mr. Jon H. Peterson,
Supervisor of Instructional Media
Department of Education, Commonwealth of Virginia

73 With assistance from the following industrial and governmental agencies:

(no narrative -- allow time for credits to be read)

END PART I

FOCUS SLIDE Engineering: An Introduction to the Field and Its Careers - Part II

slide #	narrative
1	We will now consider the engineering team and the variety of careers found in the field of engineering technology.
2	Nearly all work in engineering involves working as part of a team and engineering positions can be defined in terms of the members of the engineering team. Some call it the technical team.
3	The team structure requires effective communications. This may be oral, written, or electronic communications.
4	Engineering graphics is a primary means of communications used by the engineering team and involves drawings, graphs, and computer aided design, commonly called CAD.
5	Team members often make formal presentations.
6	There are many names given to positions in engineering and most fit under the team titles of scientist, engineer, technician, craftsman, and technologist. Craftsman, while a common term for the team members who use their hands for skill jobs, is a sex stereotyping term.
7	With more and more women entering crafts, the term craftsperson is more appropriate--just as the term draftsman has been changed to drafter in order to welcome women for their important contributions to engineering.
8	Let us look more closely at the team members--beginning with the scientist.
9	As themost theoretical member of the team, the scientist develops basic ideas known as hypotheses from which develop theories and laws.
10	Scientists conduct research with experimentation to prove theories . . .
11	and employ scientific principles to develop and evaluate products and processes.
12	Scientists receive extensive education, and most hold master's degrees or PhDs with 8 to 10 years of college education.
13	Engineers use the basic principles developed by scientists for problem solving efforts that involve systems, products, and procedures including standards and specifications.

14 Engineers work in a wide variety of settings ranging from offices with sophisticated computer systems . . .

15 to drydocks and aboard ships . . .

16 in prototype development laboratories for automobile manufacturers . . .

17 and on the manufacturing lines . . .

18 in research labs for robotic systems . . .

19 and in material testing facilities.

20 There are a number of routes to becoming an engineer. The most direct is by earning a bachelors, or graduate, degree from an accredited engineering program.

21 These programs require a great deal of scientific and mathematical knowledge for the study of engineering courses.

22 Not all of those who hold the title of engineer have an earned bachelor's degree in engineering. Currently, many engineers are those who have worked their way up to the position through apprenticeships, skilled . . .

23 and technical jobs which they combined with formal education.

24 Others have Bachelor of Science degrees . . .

25 from engineering technology programs.

26 The B.S. in engineering technology is a 4-year college program that often builds on a 2-year technology degree. This program is commonly referred to as a 2 plus 2 program. In it the student studies 2 more years to complete the Bachelor's of Science degree in engineering technology or industrial technology.

27 The difference in the engineering degree and the technology degree is seen in the level of math and science. Looking at the first 2 years of a mechanical engineering program, we see a higher percentage of math and science . . .

28 than in the first two years in a technology program. Here the student studies more technology courses involving laboratory work and applied engineering.

29 In the last two years, both programs emphasize the engineering specialty, but the engineer student uses much more math while the technology student develops more skill in laboratories.

30 The next member of the engineering team is the technician.

31 These women and men employ both skill and knowledge in their work with all phases of engineering.

32 Technicians typically are graduates of apprenticeship programs and/or hold Associate of Applied Science degrees.

33 As we previously learned of their education . . .

34 technicians combine hand skills and technical knowledge in their work.

35 This is often very specialized information and skill . . .

36 involving sophisticated equipment and procedures.

37 Among the kinds of activities technicians engage in are design and drafting, manufacturing, . . .

38 testing . . .

39 and maintenance.

40 Technologist is the next team member. This term has several meanings.

41 It often refers to those people who earn the 4-year Bachelor of Science in Technology.

42 Others use the term to describe all members of the technical team. Still others use it to cover advanced members of the technical team. But one area most agree . . .

43 is that those who work in technology must communicate effectively to meet societies needs.

44 Finally, we come to the crafts people. This is the largest group of our team members.

45 Skill marks craft work.

46 Whether in manufacturing . . .

47 and inspection . . .

48 or construction, crafts people should possess a high degree of skill to manipulate tools, equipment, and materials.

49 For more reasons than we have time to discuss, many of the skill-oriented jobs done by people in the crafts are being eliminated. Among the forces to change these jobs are the application of computers in automated devices, such as computer aided design used in computer integrated manufacturing . . .

50 to communicate design directly to machines, such as robots . . .

51 used to assemble parts formally assembled by human hands.

52 Today, robots possess abilities to see (perceive?); they have a sense of touch, recognize sound, sense changes of temperature, and even speak.

53 Changes in jobs in the future will reflect the greater need for human creative abilities and away from manual skills.

54 To deal with the sophistication fostered by high technology, interdisciplinary approaches must prevail . . .

55 especially to manufacture quality products that meet the needs of more selective consumers.

56 Many challenges face engineering and most will involve problem solving, because that is the central activity of the field.

Produced by the Technology Education Service Staff
Department of Education, Commonwealth of Virginia

57 Developed by Dr. James A. Jacobs
School of Technology, Norfolk State University

Narrated by Mr. Raymond T. Jones, Coordinator
Public Information, Chesapeake School Division

Technical assistance by Mr. Jon H. Peterson
Supervisor of Instructional Media
Department of Education, Commonwealth of Virginia

58 with assistance from the following industrial and governmental agencies:

(no narrative -- allow time for credits to be read)

END PART II

)CUS SLIDE Engineering: An Introduction to the Field and Its Careers - Part III

slide #	narrative
1	Now that you have a general idea about the engineering field and its related careers, let us look at the engineering method.
2	Research serves to develop basic ideas or principles that are later refined into useful systems or products. Usually, scientists are responsible for this research activity.
3	Research may produce a new material or process.
4	Once the new idea is available the next stage, known as development, begins.
5	Development involves creating a means to turn the fruits of research into useful products and systems to serve society. Modeling is often used in development; it may be a computerized, mathematical model, . . .
6	a scale model of a power system . . .
7	that will be built full size, . . .
8	or an architectural model used in development of a structure, . . .
9	such as the Virginia Museum of Marine Sciences. Modeling allows developmental concepts to be studied . . .
10	before undergoing construction . . .
11	to avoid wasting resources that might result if the problem was not studied at small scale.
12	Sometimes technical illustrations, or renderings, are used instead of models.
13	From development comes detailed design. Each component is drawn . . .
14	and given exact specifications to ensure that it is manufactured to meet design requirements.
15	To gain a better understanding of the manufacturing stage, we will look at a specific product to see how the engineering method is completed. The following sequence of slides depicts the variety of engineering involved in the manufacturing of semi-conductors used for logic and memory modules in computers. The high technology operation begins with silicon wafers and uses highly automated processes to produce modules which in turn are shipped to other plants that assemble the computers.

16 Working at a CAD terminal, this graduate electrical engineer lays out the electrical support system for the manufacturing building.

17 A mechanical engineer lays out the structural support for the building . . .

18 while a civil engineer completes the equipment layout.

19 Another civil engineer has responsibility for air abatement to remove any contamination before the plant air is released into the environment.

20 This graduate of a chemical engineering program monitors a liquid chemical system used to process the semiconductors.

21 To ensure that ground water for wells is protected, the plant employs two two environmental engineers; one of whom holds a master's degree in his field.

22 Close control of industrial waste is necessary when chemical processing is a part of manufacturing. An Associate of Applied Science in Environmental Science degree prepared this technician to be a part of the team effort in maintaining Environmental Protection Agency standards.

23 Not all engineers hold degrees. Here is an individual who has combined work experience with self-education and company educational programs to become a valued manufacturing engineer.

24 Scientists are also part of the manufacturing team; as with this solid state physicist who checks a prototype design of a robot gripper intended to handle silicon wafers.

25 Mechanical engineers have responsibility for keeping the manufacturing systems operational. This nitrogen pump required rebuilding.

26 While automation may replace production workers, many technicians are needed to maintain high tech production lines.

27 The combined efforts of electronic and mechanical technicians come together to change a component for the manufacturing test system.

28 An oscilloscope serves to calibrate test circuits and is used by an electronics technician.

29 Block diagrams of circuits aid in analysis to improve response time, productivity, and reliability of a semiconductor tester.

30 A graduate of an AAS Computer Science Technology program works with an AAS degreed electronics technician to review circuit specifications before modifying the circuit panel in the background.

31 Automated materials handling equipment includes robots. Here a graduate of a mechanical engineering program compares design specifications with the prototype robot that was adapted for component testing.

32 Specially designed electronic probes and a microscope reflect the nature of equipment required for the minute components found in micro-manufacturing of semiconductors. The AAS technician tests individual transistors on a sample wafer.

33 Two other AAS electronic technicians perform visual inspection of processed wafers for surface defects. All components receive automated testing and inspection; additionally, sampling techniques help verify reliability of the automated testing.

34 Using a microcomputer and a statistical analysis program, this technician evaluates test data.

35 To this point, you have seen the variety of activities and disciplines required to support semiconductor manufacturing. Now we will take you on a quick trip through the complete process. It begins with the silicon wafer which is transformed into a group of very large scale integrated circuit chips, which are diced into individual chips, then mounted into modules.

36 The silicon is a synthetic ceramic, first made into an ingot or film by various techniques.

37 Silicon ingots are sawn into thin wafers with a diamond saw.

38 Next they are polished.

39 The silicon wafers are single crystals . . .

40 that need to be doped with metallic elements to give them semiconducting properties.

41 Various techniques implant metallic elements in precise locations on the wafers.

42 Photolithography is employed to protect the silicon that should not receive doping.

43 Wafers are loaded into a sealed quartz tube ready for insertion into a diffusion furnace that will diffuse the dopant at temperatures of 1100 to 1300 degrees Celsius over a period varying from 30 minutes to 2 hours.

44 After doping, the wafer has micro circuits which serve as computer logic and memory modules.

45 The wafers must have metal on the surface for soldering to substrates. This technician mounts assembled wafers with masking onto the evaporator which will deposit the metal terminals.

46 Microprocessors control the evaporation process.

47 This is a completed semiconductor wafer.

48 The wafer is then diced into individual semiconductor chips.

49 Each chip is automatically aligned onto an aluminum oxide ceramic substrate . . .

50 and soldered to the metal pins that were earlier inserted into the substrate.

51 Modules are automatically stacked for encapsalating.

52 Here we see the raw silicon and the various stages of the module with a variety of the aluminum encapsaled modules.

53 Throughout the processing, quality checks are made by technicians . . .

54 who also provide maintenance support.

55 Each module receives a complete operational test . . .

56 then is readied for shipment to the next factory for assembly into a computer.

57 This listing shows the various discipline involved in production of these very complex semiconductor modules. But notice the list does not include the many supporting engineers, technicians, and scientists who deal with such important concerns as the manufacturing, building, control of waste, and environment.

58 These are typical job assignments held by the engineering team for semiconductor engineering.

59 Education continues for all members of the team. Some is company training and other is formal education from colleges and universities. Rapid changes in technology dictate lifelong learning.

This program has provided you with a glimpse at the field of engineering. We hope you will be motivated to explore further in this dynamic field.

Produced by the Technology Education Service Staff
Department of Education, Commonwealth of Virginia

60 Developed by Dr. James A. Jacobs
School of Technology, Norfolk State University

Narrated by Mr. Raymond T. Jones, Coordinator
Public Information, Chesapeake School Division

Technical Assistance by Mr. Jon H. Peterson
Supervisor of Instructional Media,
Department of Education, Commonwealth of Virginia

61 with assistance from the following industrial and governmental agencies:

(no narrative -- allow time for credits to be read)

END PART III

PROGRAM:1
Slide/Tape

IMPORTANT QUESTIONS
FOR
POTENTIAL ENGINEERS

Do I have an inquisitive, searching mind?

Do I like to solve problems and puzzles?

Do I like to create things?

Do I enjoy learning?

Can I organize my time?

Am I willing to work hard?

Prepared by Mr. Ken Anderson, Consulting Engineer; Anderson Associates, Blacksburg. VA

202

TRADITIONAL BRANCHES

CHEMICAL

CIVIL

ELECTRICAL

INDUSTRIAL

MECHANICAL

WHAT DO THEY DO ?

Engineers find practical applications for abstract scientific principles.

They are inventors.

- developers of new products
- designers of buildings , bridges, automobiles, and airplanes
- creators of labor saving devices for home, office, school, and factory.
- designers of cities and towns

THE ENGINEERING TEAM

ENGINEER

B.S. in Engineering
May or may not be registered
Applies theory
Leads team

TECHNOLOGIST

Baccalaureat degree after
four years of study
Understands theory

TECHNICIAN

Associate degree (2 year)

CRAFTSMAN

Experience

WHERE DO THEY WORK ?

60% Industry

20% Government

10% Private Practice

5% Construction

5% Education

WHAT CAN I EXPECT TO EARN ?

Start	$ 20,000+
Median	$ 47,000

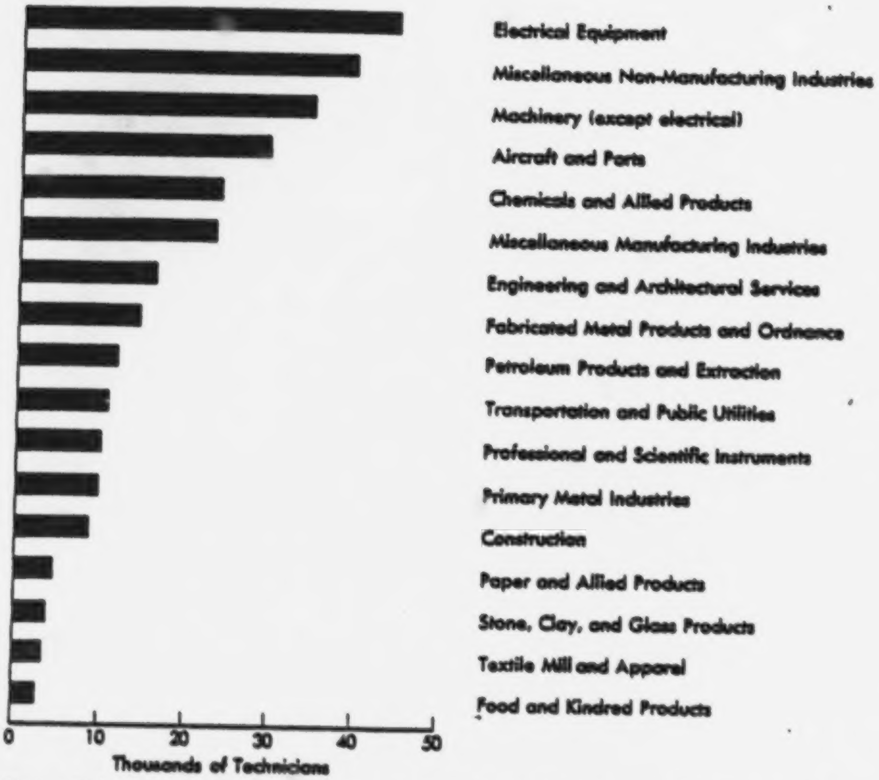
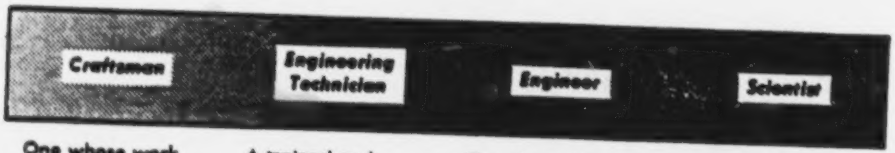


Figure 9–6. Distribution of engineering and physical science technicians by industry in 1960.



One whose work involves repetitive or manipualtive skills.

Skilled labor, individual effort. Seldom supervises the work of others.

A trained and skilled person whose work involves the application and execution of designs of an engineering or scientific nature. Practices state-of-the-art. May also supervise the work of skilled labor.

Translates the findings of science into usable forms by his designs. Develops new principles and methods useful to man.

Work usually involves a high degree of creativity. Frequently supervises the work of the engineering and scientific team.

Searches for new knowedge concerning the nature of man and the universe. Infrequently involved in supervisory work.

Figure 9–1. Occupational spectrum.

CAREERS IN THE COMING DECADE

The future appears bright for engineering, math, and science students. Here is a partial list of the projections made by the United States Department of Labor's Bureau of Labor Statistics. The figures show the number of new jobs expected between 1982 and 1995 and the percentage gain those numbers represent. A growth rate of 20-29 percent is considered average.

Occupation	Number of New Jobs	Percentage (+) Gain
Surveyors	19,000	43
Engineers (all fields)	584,000	49
Aerospace engineers	18,000	41
Chemical engineers	24,000	43
Civil engineers	73,000	47
Electrical engineers	209,000	65
Industrial engineers	67,000	42
Mechanical engineers	109,000	52
Metallurgical engineers	6,600	47
Mining engineers	1,300	22
Nuclear engineers	3,000	48
Petroleum engineers	5,700	22
Computer-systems analysts	217,000	85
Mathematicians	3,000	26
Chemists	20,000	22
Geologists and geophysicists	11,000	24
Physicists	6,900	37
Agricultural scientists	4,000	19
Biological scientists	19,000	36
Lawyers	159,000	34
Physicians	163,000	34
Computer programmers	205,000	77
Computer technicians	53,000	97
Drafters	15,000	5
Electrical/electronic technicians	222,000	61

From "Careers '85," *The New York Times*, October 14, 1984.

Resources in Technology

Careers in Technology

Even the most casual observer recognizes that technology continues to accelerate at an ever-increasing rate as it spews out one innovation after another. But how many stop to consider how this advancing technology promises to affect their careers? Requirements for many of today's jobs have already changed; however, most people do not realize it until they begin considering a job change. When they look for a new position under their present job title, they may be shocked to learn that the new position requires knowledge and skills that they do not possess.

In the near future, many jobs will be eliminated and even more will crop up to replace the obsolete ones. In the distant future, but still within the working life of younger employees, making predictions about the job scene will become an impractical task.

This Resources in Technology will allow you to examine some of the forces that create change in occupations, see the types of newly-developing and much-needed careers fostered by the driving forces, and learn how to pursue education and training in preparation for entering a career that appeals to you. Limited space permits us to develop only some basic, but key, concepts that will make you a wiser evaluator of careers. These concepts can help equip you to deal with the lifelong task of learning about occupations and to keep current with occupational changes.

Social—Cultural Impacts

The United States has lost its ability to meet global competition as Japan, Germany, and other nations have surpassed the U.S. in quality and low or moderately priced products, ranging from televisions to automobiles to industrial equipment, such as machine tools and robots. Japan's productivity is five times that of the U.S. These factors contribute to a large trade imbalance between nations, with the U.S. sending more money abroad than it is receiving. With this imbalance of trade, the U.S. may lose many jobs for its citizens. To regain its competitiveness, U.S. industry must increase productivity.

The movement toward improved productivity and better quality products involves automation, which means many manual jobs disappear. That is the bad news. The good news is that automation creates a need for more technologists. The term *technologist* has several meanings. Here it means engineers, technicians, and scientists—those people with technical knowledge and skills. John Young, the president of Hewlett-Packard and chairman of the President's Commission on Industrial Competitiveness, stresses the need to consider education as a lifelong process and says we must prepare to provide continued retraining for adults (Young, 1985).

Projections of future jobs reveal a serious mismatch of requirements for the new jobs and preparation of those seeking the positions. People displaced by new technology may seem logical candidates to fill the new jobs created by that same technology; however, they often lack the prerequisite knowledge, skill, and attitude to qualify for retraining. In an article on the growing mismatch between jobs and job seekers, Drucker (1985) points to the need for people to possess certain attributes for them to be retrainable. These people need "technological literacy," a fair theoretical base in basic sciences, and an attitude that enables them to adjust to change.

The editor of *High Technology* informs us that our current skilled and semiskilled workers will not only be displaced from their jobs by automation; but even worse, a large segment of the younger generation will lack preparation to deal with demands of tomorrow's high-tech world, thus preventing them from filling the new positions. This prediction results from the fact that many school districts do not provide the proper education to deal with the kind of technically oriented occupations for the future. A growing population of unemployable citizens may develop in central cities, rural areas, and the "rust belt" (steel- and auto-producing states), while high paying and frequently changing jobs develop in technology-based communities (Haavind, 1985).

Evidence of the need for technically competent workers abounds in employment advertisements, such as those seen in *Commline: The Journal of Computerized Manufacturing*. One issue listed current base salaries for jobs that ranged from $50,000 for NC (numerical control) and CNC (computer numerical control) managers, to $44,300 for CAD (computer-aided design)/CAM (computer-aided manufacturer) engineers, to $34,000 for a long list of technicians in NC, CNC, and CAD/CAM positions ("NC/CAD/CAM," 1985). Predictions through 1995 by the U.S. Department of Labor's Bureau of Labor Statistics show a bright future for people educated in engineering, math, and science. In the comparisons of percentages of increases over those employed in 1982, the following samples indicate the typical gains anticipated by 1995: engineers in all fields—49%, industrial engineers—42%, metallurgical engineers—47%, electrical engineers—65%, mechanical engineers—52%, electrical/electronic technicians—61%, drafters—5%, computer programmers—77%, computer technicians—97%, mathematicians—26%, chemists—22%, lawyers—34%, physicians—34%, computer-system analysts—85%, agriculture scientists—19%, and biological scientist—36% (*NY Times*, 1985).

The above statistics have many implications for the occupational outlook for countless job categories. Obviously, we cannot deal with all of them here, rather we will focus on the engineering team because the team members must play a role in increasing the world trade competitiveness of any nation. A nation should enjoy a good standard of living with a good balance of trade.

This Resources in Technology was written and prepared by Tidewater Technology Associates (T^{2}A), an educational consulting group that specializes in technical programs, curriculum, and instructional development. Members of the organization are John M. Ritz, Paul L. Cummings, Walter F. Deal III, Martin M. Foy, W. Fred Hooker and James A. Jacobs. Further inquiries to T^{2}A can be made by contacting John M. Ritz, 7045 Downman Dr., Norfolk, VA 23518, (804) 855-9206.

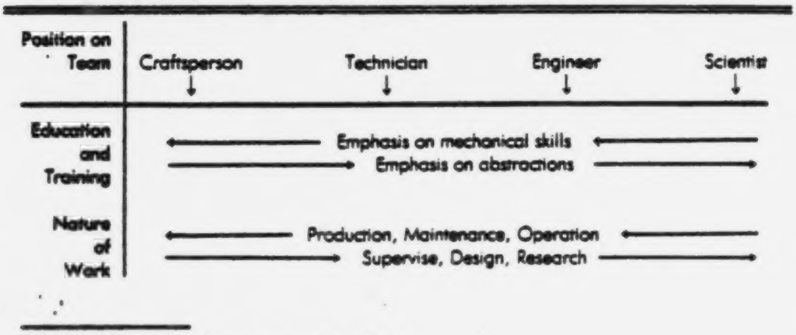
The Engineering Team

We begin our study with the engineering team because most work done in engineering involves a team effort. The team members include scientists, engineers, technicians, and crafts people. Sometimes the term *technologist* is used in labeling a specific team member; however, the term has several meanings, with many using it to designate any member of the technical or engineering team. Our discussion will avoid the technologist.

The engineering team (also known as the technological or technical team) centers much of its activity around problem solving. This means team members constantly look for solutions in such areas as malfunctions of equipment, new and improved techniques to processes, chemicals, better manufacturing techniques, or clearer and more precise methods to communicate technical ideas. When learning the descriptions of team members, keep in mind that all members should be good at critical thinking. They must possess the ability and willingness to revise judgments in light of newly presented principles or findings. They need to view problems objectively and without interjection of personal biases and must employ creativity.

FIGURE 1

The Engineering Team: Relationship Between Positions, Education, and Nature of Work



Direction of arrows indicate increased emphasis

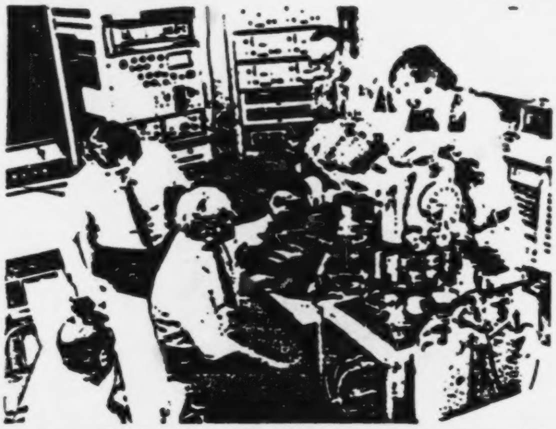
Scientist

The scientist comes first in this discussion because much of the time, this kind of technical person originates the basic ideas upon which other members of the team build. As the most theoretical member of the team, scientists develop hypotheses, from which come theories and laws of science. Their activity requires much investigation of the phenomenons of the universe. Many years of experimentation may go into an effort to explain matters that seem minor. But in science, explanations of the smallest details help with the large puzzles of the universe. For example, much effort in science today focuses on determining the nature of the nucleus of atoms. Scientists want to discover all the particles in the atom and determine how they help to hold matter together. This study goes back to the beginning of science and has yet to be completed.

These theoretical scientists may have little concern with the practical application of their discovery and leave that to other members of the technical team. Some scientists, who may be labeled applied scientists, do engage in practical problems. For example, materials scientists, polymer chemists, and metallurgists use theories and laws of science in their research on new materials for engineering. Today, considerable research goes into materials that will make lighter, longer lasting batteries to replace the lead acid batteries currently used in automobiles.

Scientists require a strong academic background and usually study for seven to nine years in colleges to earn a doctorate degree. Like most of the members of the engineering team, their education does not stop with the doctorate; they must continue to study the remainder of their working life.

The diagram in Figure 1 shows a comparison of the members of the engineering team. With scientists, the nature of their education and the nature of their work places emphasis on mathematics and sciences, such as physics and chemistry.



A team of scientists involved in the development of a process for making semiconductor crystals.

A CAD station allows a design engineers to speed the design process many times over manual drafting.

Engineer

Engineers use the basic principles developed by scientists for problem-solving efforts that involve systems, products, and procedures that incorporate standards and specifications. Practical applications of scientific discoveries drive the engineer. They strive for improvement and must always wonder if a "better way" might be found for a present process, product, or procedure.

Many areas of specialization exist in the field of engineering. Figure 2 lists but a few. These fields cover the areas in which all members of the engineering team may find employment. Later you shall see that much specialization also exists within the engineering fields of specialization.

The most direct route to becoming an engineer is to complete a bachelor's of science degree or master's of science degree in engineering from a college or university accredited by ABET (Accreditation Board of Engineering and Technology). These engineering degree programs require extensive study and use of mathematics and science. One must have an aptitude and strong interest in math and science to succeed in traditional engineering programs.

Other less direct routes exist for entry

FIGURE 2
Specialized Fields of Education

Aeronautics
Aerospace
Agricultural
Architectural
Bioengineering
Ceramic
Civil
Electrical
Industrial
Manufacturing Systems
Marine
Materials
Mechanical
Metallurgical
Mining & geological
Naval
Nuclear
Petrochemical
Semiconductor
Structural

into positions entitled **engineer.** Many people employed in private industry with this title did not graduate from an ABET-accredited engineering program. This group of engineers may have served apprenticeships, gained much work experience, and supplemented their education through company-sponsored programs. The combination of work experience, and education make them valuable employees. However, these people may find that their experience would not guarantee them a position of engineer if they sought work with another employer.

Still another route exists for moving to the rank of engineer. This route involves study in **industrial and engineering technology** programs. These relatively new programs may be ABET accredited or accredited by NAIT (National Association of Industrial Technology). The degrees are known as bachelor's of technology, bachelor's of engineering technology, or bachelor's of science in technology. Normally, these programs do not require as many math and science courses, even though they do involve application of both. More emphasis goes into laboratory work, skill development, and applied engineering. These people prove themselves as field engineers in CAD/CAM and NC work or other areas where equipment and manipulative skills are needed. Many first complete an AAS (associate of applied science degree) at a community or junior college and then go on to finish their bachelor's degree in a four year college or university. A 2 plus 2 program is the popular name for this route to a bachelor's degree.

Technicians operating a modern steel mill.

Technician

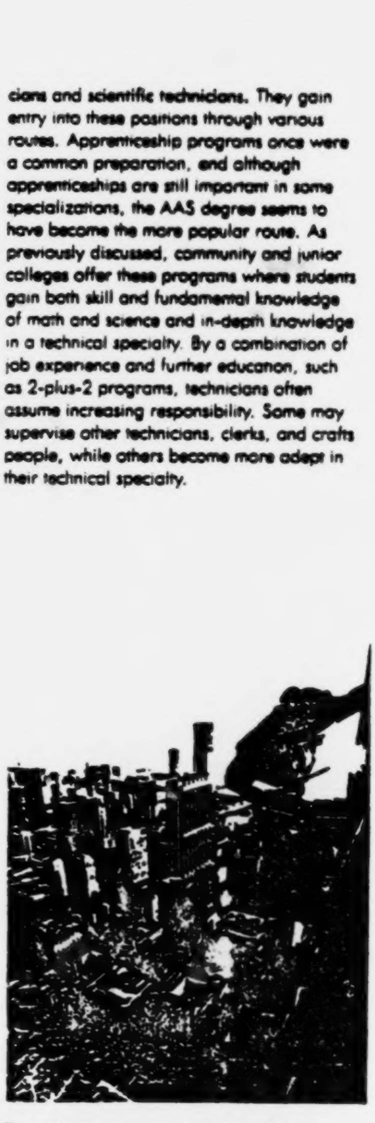
Technicians employ skill and knowledge in all phases of engineering depicted in Figure 2. As seen by the emphasis in Figure 1, technicians rely on familiarity with tools, equipment, and apparatus. They often undergo specialized education and training that emphasizes manipulative skills, such as with mechanical or electrical testing equipment. They may work on production lines as troubleshooters to keep the equipment running. In construction, they use such instruments as transits or levels. They maintain sophisticated equipment, such as computers, NC tools, aircraft, and spacecraft. Some operate CAD systems in design/drafting jobs.

Two groups of technicians related to the technological team are **engineering technicians and scientific technicians.** They gain entry into these positions through various routes. Apprenticeship programs once were a common preparation, and although apprenticeships are still important in some specializations, the AAS degree seems to have become the more popular route. As previously discussed, community and junior colleges offer these programs where students gain both skill and fundamental knowledge of math and science and in-depth knowledge in a technical specialty. By a combination of job experience and further education, such as 2-plus-2 programs, technicians often assume increasing responsibility. Some may supervise other technicians, clerks, and crafts people, while others become more adept in their technical specialty.

Crafts Person

Skill marks the craftsmen group as we see in Figure 1. They use hand tools, operate machines (e.g., lathes, forging presses, or welders), and may service and maintain equipment. Crafts people should have a great pride in quality work and derive satisfaction from seeing materials transformed from their raw state to finished products. Education for the crafts usually involves completion of a high school vocational program. Or, some students may finish industrial arts/technology education courses. Certification in a craft often follows an apprenticeship after high school.

The onslaught of technology and automation means the need for many crafts people will diminish, while more technicians and engineers must fill the work force. This also applies to semiskilled and labor jobs. No one could wisely predict that laborers and crafts people may eventually be completely eliminated by automation and robots. In fact, certain service jobs (e.g., janitorial work and food and health service) should increase. People will always yearn for handcrafted products, but the price may be beyond most.



This welder represents the many skilled craftspeople employed in the construction industry.

The Team Approach

In most engineering activities, you will see the team approach in operation. Often, it is hard to distinguish the team members as they go about the task on problem solving. A recent visit to a plastic manufacturer showed this to be true. In the development lab, the chemist and chemical technicians had developed a new processes for producing polystyrene plastic. The process was an experiment involving glass, rubber, and metal laboratory apparatus. To verify that the processes was feasible, a small pilot plant was being constructed.

At the beginning of the visit, the team of scientists, engineers, technicians, and mechanics was busy working on the pilot plant. The grease and soot revealed all had pitched in on the job. Without introductions, it would have been impossible to determine the members' positions on the team. Once the pilot proved successful, the new process was scaled up for high-volume manufacture of polystyrene in a full-sized plant.

Figure 3 lists a very small sampling of job titles within the various levels of the engineering team. Consult other sources, such as the *Dictionary of Occupational Titles* and *Occupational Outlook Handbook*, for more titles and descriptions of jobs in engineering. Note the responsibilities and relationships for each team member described.

FIGURE 3
Sample Jobs in Engineering Field

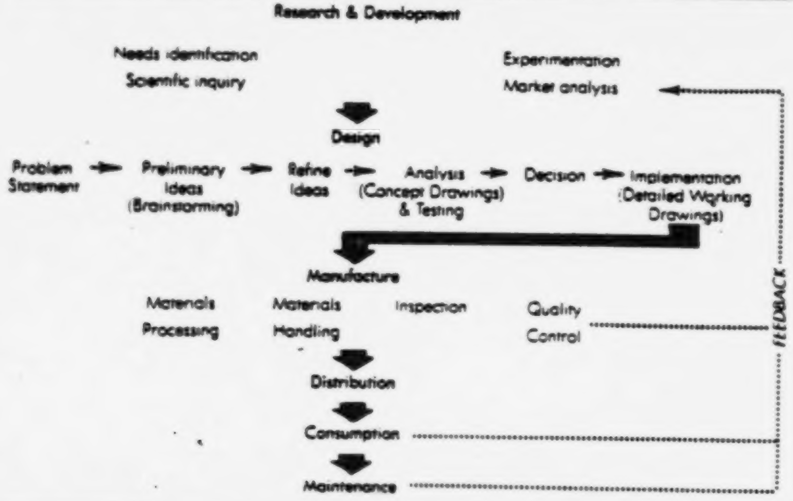
Scientist	Engineer	Technician	Crafts Person
Geologist	Aeronautical engineer	CAD designer	Automotive mechanic
Geophysicist	Civil engineer	Computer programmer	Carpenter
Nuclear physicist	Customer engineer	Electronic troubleshooter	Diesel mechanic
Nuclear physicist	Design engineer	Engineering repair technician	Drafter
Petrochemist	Electrical engineer	Estimator	Heating & A/C Mechanic
Polymer chemist	Field engineer	Mechanical technician	Machinist
Solid-state physicist	Manufacturing engineer	NC programmer	Mason
	Production manager	Robotic technician	Pipe fitter
	Quality engineer	Solar technician	Welder
	Surveyor	Wind tunnel technician	
	Welding engineer		

Predictions of changes in manufacturing show a closer team structure. Quality circle techniques place more responsibility on all members of the team and put greater control in the hands of crafts people and technicians. Some see fewer managers needed as factories eliminate foremen and time clocks as they place production workers on straight salaries. Such an approach is designed to increase employee sensitivity to the competitive pressure on the company from other companies and from foreign trade. It should also improve communications among various levels on the engineering team and among the functions of the team (e.g., development, design, manufacturing, quality control, and maintenance) (Brody, 1985).

Engineering Functions

Figure 4 serves as a means to understand the functions of engineering. Beginning at the top, research produces the seeds of ideas which go through further growth in the development stage. Once ideas have germinated in "R&D," they undergo detailed design: a lengthy process which requires consideration of the smallest aspects of the process or system under consideration. CAD holds promise as a means of speeding up the design process.

FIGURE 4
Engineering Functions

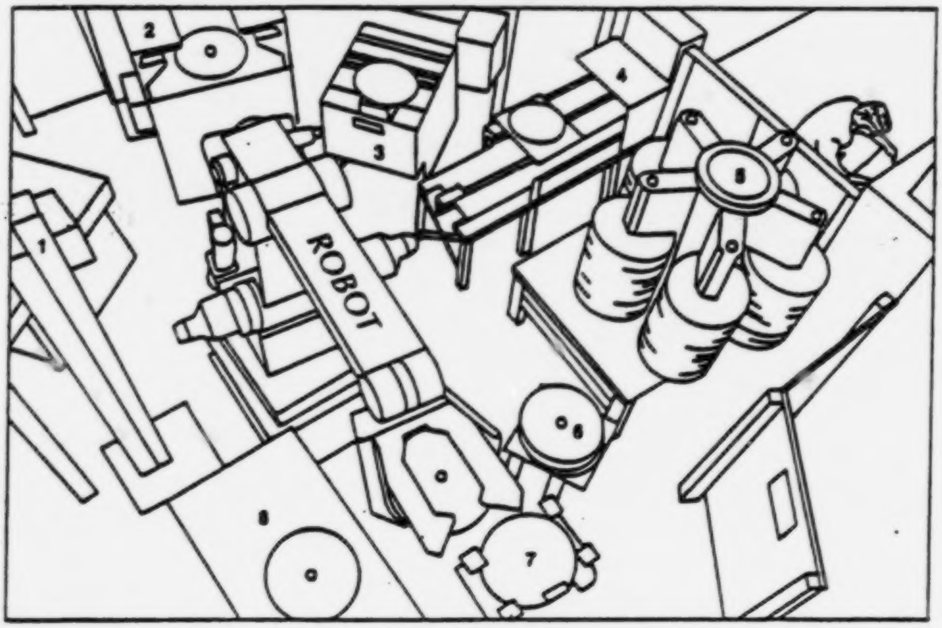


Guided by the completed design and with working drawings, the production team begins to manufacture the product or system. CAM provides a means to automate manufacturing. With CAD systems, the computer-generated data is capable of directly controlling NC machine tools, robots, and automated materials handling equipment. Note the feedback indicated by broken arrows.

"Feedback" refers to verbal information from one team member to another or electronic information sent from machines to humans or machines to machines. This information allows people in any of the functions, from research down, to learn of problems with their ideas so that they may make modifications to solve the problems. For example, once production begins to manufacture a part, they may see that a certain material does not hold up to the bending done on presses. With this feedback data, a new material may be substituted; or perhaps the thickness might be changed and the bending equipment modified.

Figure 5 depicts an automated process, which is one of many steps in manufacturing semiconductor modules. Such modules act as memory and logic devices in computers. The robot in the center of this diagram has elimi-

FIGURE 5
Automated Sintering Furnace Process



1 View machine
(measures tiles)
2. Scraper
3. Tile washer
4 Shuttles
(Link between system and operator)
5 Index table
(tile storage)
6. Reject table
7 Breaker
(breaks down, unloads tiles)
8. Hydraulic lift table
(Picks tile off table)

nated a number of steps formerly requiring human handling of containers of multilayered ceramic (MLC) modules as they are sintered in a high temperature furnace (1560° C).

Sintering turns soft "greenware" ceramic into hard ceramic. The robot retrieves tiles from storage (station #5), moves them to #2 for both sides to be scraped (bushed and vacuumed), and moves to #3 for washing and hot-air drying. Next, at station #1, an optical measuring machine checks tiles for flatness. Faulty tiles are placed on #6. Good tiles are moved to the shuttle (#4) which transports them to the human operator who assembles the tile containers with MLCs in them. The operator returns the assembly to shuttle where the robot moves them onto a stack at #8. The assembled tile container is now ready for the sintering furnace. Station #7 allows the robot to separate tiles that may be stuck together from sintering (*The Circuit*, 1984).

Robotics provide the engineering team with new machinery for many functions in engineering. Hard automated devices require considerable time, money, and effort to set up and change over for new processes. On the other hand, robots can be reprogrammed with a minimum of time and effort. An engineer or technician might develop several computer programs for the robot. With this ceramic handling processes, the robot could have different programs allowing it to handle different parts.

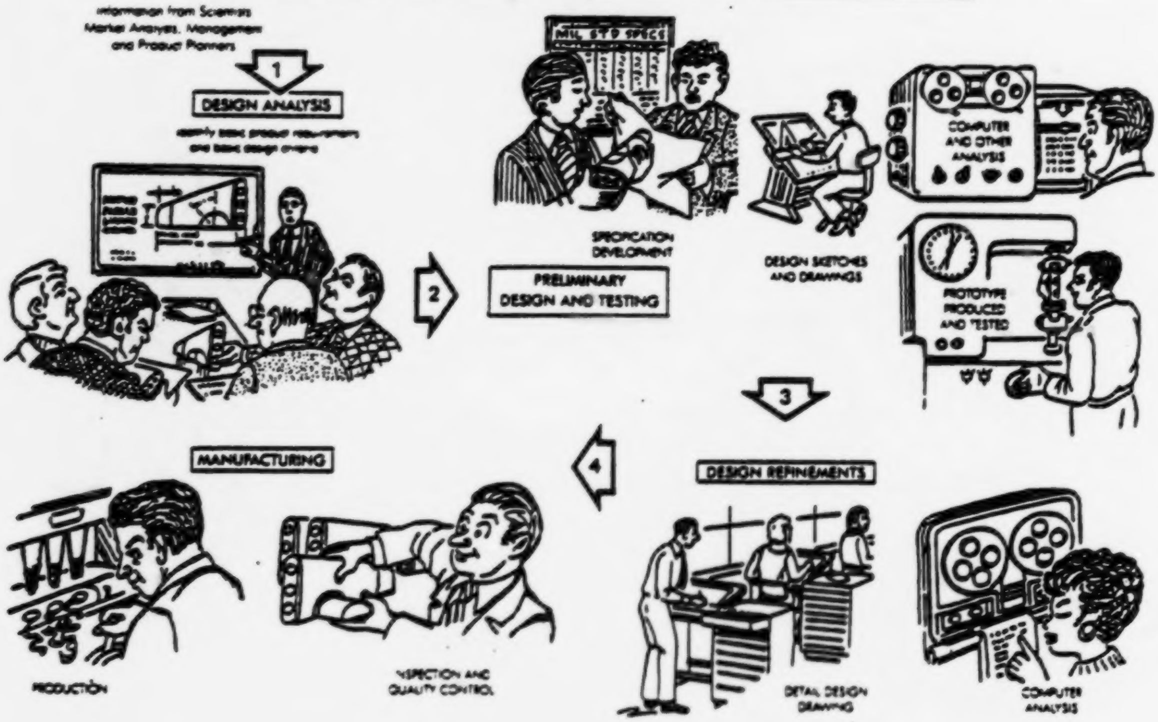
Figure 6 shows the engineering team functioning through various operations to amplify Figure 2. Notes that from preliminary design and testing, a prototype device is produced and tested. This prototype serves to avoid major problems with full-scale production. Just as the pilot chemical plant was first made to produce polystyrene plastic, a small-scale pilot plant may be used to make prototype parts to prevent major problems in full-scale production.

Referring back to Figure 4, we note that engineering functions do not cease once products are manufactured. They become involved in the distribution of products by many means. Distribution can involve ground travel (rails or roads), water, air, and even pipeline. Members become involved in consumption as they work as customer/sales engineers, technical writers, mechanics, and technicians to install products and systems.

Finally, going back to Figure 4, we see the need for the engineering team in maintenance. The service area of engineering has grown as do-it-yourself maintenance becomes difficult as many electromechanical products are very sophisticated. The job outlook for service technicians looks good.

Both consumption and maintenance stages provide feedback to earlier functions of engineering. The feedback feature reinforces our earlier comment that engineering should always be alert to a better means for problem solving.

FIGURE 6
The Engineering Team in Product Research, Development, and Manufacture


Information from Scientists
Market Analysts, Management
and Product Planners
1
DESIGN ANALYSIS
identify basic product requirements
and basic design criteria
2
PRELIMINARY
DESIGN AND TESTING
MIL STD SPECS
SPECIFICATION
DEVELOPMENT
DESIGN SKETCHES
AND DRAWINGS
COMPUTER
AND OTHER
ANALYSIS
PROTOTYPE
PRODUCED
AND TESTED
3
DESIGN REFINEMENTS
4
MANUFACTURING
PRODUCTION
INSPECTION AND
QUALITY CONTROL
DETAIL DESIGN
DRAWING
COMPUTER
ANALYSIS

Research Activity

Now that you have an introduction to the engineering team, the next step involves pursuing information on a position or positions which interest you. This research activity is designed to accomplish two goals: (a) to find out more about an occupation that you find appealing, and (b) to develop a methodology for gaining career information that will serve you for a lifetime.

The first step in developing information about careers of interest has already been taken when you read this unit of instruction. Also, you have observed people at work, made judgments about the kind of activity that you saw, and learned about conditions of employment. For instance, television carries many detective programs that show a great deal of excitement and romance. If you spend several days with a detective you may see some excitement, but you would also see that most detective activities involve in such routines as spending long hours observing people and filling out forms.

This is a problem in trying to study careers; what is on the surface is not the full picture. Being an engineer seems quite appealing when one views the challenges of problem solving and learns that many well-paying jobs exists for engineers. However, becoming an engineer requires a lot of hard schooling plus an aptitude and strong interest in the courses one must complete in engineering schools. Beginning your analysis early about careers is wise and will help you arrive at a well-considered choice.

The following general procedures should aid your search:

1. When watching educational films, observe the jobs portrayed;
2. Occasionally glance at newspaper ads to determine the types of positions available, the requirements, and salaries.
3. Ask relatives and acquaintances about their jobs.
4. Watch for news stories about job trends, contributions made by workers, and conditions in various jobs.
5. Be alert for people who are working in your area on construction jobs, in service positions, or any place where the opportunity to ask questions develops; most people like to talk about their work.

Next, follow the procedures below for a more systematic, in-depth occupational analysis:

1. Begin with a class discussion centered around this instructional module.
2. Use school, public, and college libraries; counseling centers; and personal interviews, when possible.
3. Develop a career lattice like the one shown here for a manufacturing engineering; however, choose an occupation of your interest.

Some people talk about career *ladders*, but we use a lattice, like one a rose grows on. Most careers have many ways to move through them in the manner much like a rose vine climbs a lattice. Next to each level place the education normally required to reach that level. Post the various career lattices for class discussion.

Math-Science-Technology Interface

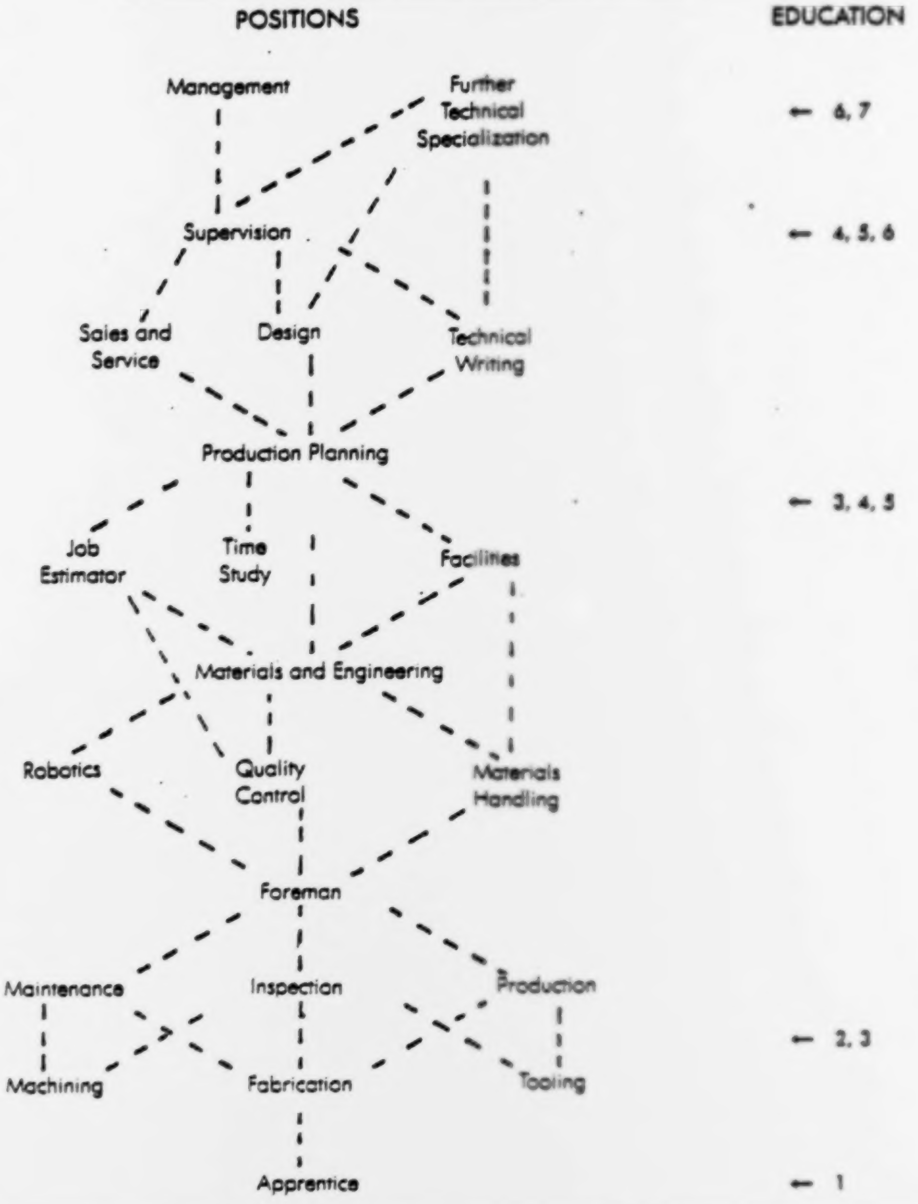
In studying the differences in the kind of preparation to enter various positions on the engineering team, you will see that some positions require more math and science than others. Figure 1 provides an indication of this relationship. It is *quite* important, however, to understand fully the prerequisite courses in math and science for entering the program of preparation for a given position on the technological team. This information may be obtained by talking to counselors and studying the brochures and catalogs on programs of your interest.

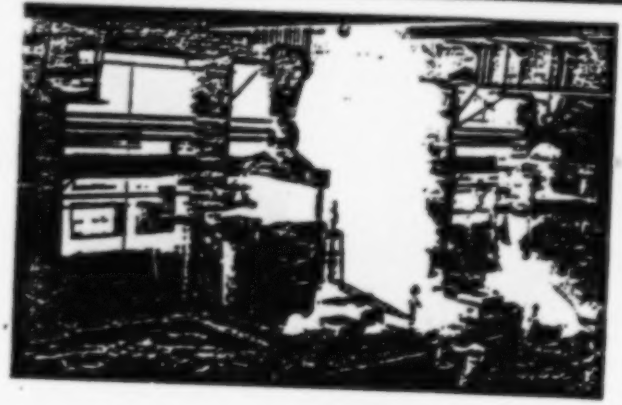
Career Lattice in Manufacturing Engineering

Figure 7 depicts a career lattice in manufacturing engineering. *Position* refers to the type of work involved in a certain area within manufacturing. These areas may include jobs for several members of the engineering team (e.g., technician, engineer, or crafts person). *Education* indicates the level of education normally required to enter these fields: 1—high school, 2—apprenticeship program, 3—associate of applied science, 4—bachelor of science in technology, 5—bachelor of science in engineering, 6—master of science, 7—doctor of philosophy. The broken lines —— between positions indicates the ability to move around on the lattice based on interest, experience, and success.

Experience acts as a key determinate that couples with education for the achievement of certain levels on any career lattice. In general, supervision and management positions provide for higher salaries; but with increasing need for technical specialization, those who distinguish themselves in their specialty should expect financial rewards on par with most management positions. Increased specialization may take the team member into research and development (R & D) or make them very valuable engineers, technicians, or scientists on several levels of the career lattice.

FIGURE 7
Career Matrix


POSITIONS
EDUCATION
Management
Further Technical Specialization
← 6, 7
Supervision
← 4, 5, 6
Sales and Service
Design
Technical Writing
Production Planning
← 3, 4, 5
Job Estimator
Time Study
Facilities
Materials and Engineering
Robotics
Quality Control
Materials Handling
Foreman
Maintenance
Inspection
Production
← 2, 3
Machining
Fabrication
Tooling
Apprentice
← 1



This foundry with numerous craft people reflects the conventional factory of today. . . .

. . . It contrasts sharply with this ultra-modern manufacturing plant, labeled the "factory of the future." In this factory—that looks much like an office, the machines make semiconductor materials for computers.

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- *Modern Talking Pictures Film Catalog* (for industry-sponsored free loan and videotapes; Modern Talking Pictures, 5000 Park St., N., St. Petersburg, FL 33709).
- *Journal of Industrial Technology* (National Association of Industrial Technology).
- *Occupational Outlook Handbook* (U.S. Department of Labor, Washington DC, current ed.)
- *Peterson's Guide: Engineering, Science, and Computer Jobs* (PO Box 2123, Princeton, NJ 08540)

Possible Student Outcomes

—Describe the technological forces that are driving changes in careers.

—List the members of the engineering team, give a short description of each, and name a job title for each member.

—Match the minimum education normally required for entry into positions on the technological team.

—Match the nature of work with members on the engineering team.

—List at least five fields of specialization within engineering.

—Construct a career lattice for a career that has a personal appeal.

—Locate and read references and consult qualified people to obtain career information.

—Develop values that relate to career preferences, and use those values in preparing for an occupation.

Student Quiz

1. Match the minimum educational level normally required to enter the four main positions on the engineering team.

(e) scientist a. high school degree
(b) engineer b. bachelor's degree
(c/d) technician c. AAS degree
(a/d) crafts person d. apprenticeship
e. master's degree

2. Name four fields of specialization in engineering. (See Figure 2.)
3. For each of the four main members of the engineering team, list two job titles. (See Figure 3.)
4. List one of the forces driving changes in many occupations. *(Automation, increased world competition, advances in technology, changing qualifications for jobs, and a need for a stronger math- and science-based education by many workers)*

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Acknowledgments

Figure 5 was reprinted with permission from IBM's The Circuit, (East Fishkill, Nov-Dec 1984, p. 5)

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Careers in Engineering, Part I

Today's Engineering Team

by Steven S. Ross

Excitement—and enrollments—has been building at the nation's 300 engineering colleges.

And why not? Opportunities abound for **engineers** and other related technical professionals. These include **technicians, technologists,** and **computer scientists.** Indeed, the roles played by such people today were hard to imagine a few years ago—even as recently as May 1983, when I last wrote about engineering for *Career World*.

In that article I said, "It now appears likely that computers will help the blind see and the paralyzed to walk again. Even the heart attack victim can get mechanical aid—and within the decade a totally mechanical heart will be within routine reach of sufferers."

A decade? We're about to lose track of the number of people alive with the Jarvik-7 heart. There's hardly a large library without a machine that reads text to the blind. And who wasn't moved to tears at the emotional sight of a paraplegic "walking" to her graduation at Wright State University in Dayton, Ohio, last year?

As amazing as these advances are, their low cost to the ultimate consumers—us—is even more remarkable. Fueled by almost daily progress in computer technology. we are enjoying everything from cheaper long-distance telephoning to better gasoline mileage.—

The author, who frequently writes about engineering, holds degrees in physics and journalism. He recently became president of Classroom Consortia Media, one of the largest developers of educational software.

Photo: Courtesy Santa Fe Railroad

Result: Probably at no time since World War II has the image of engineering been higher. Fading are the pictures of engineers-as-polluters, engineers-as-warmongers. Even the chemical-plant disaster in Bhopal, India, has been blamed more on poor management than on any shortcomings in the plant's design.

The Field Grows

Each year, more than 100,000 college freshmen enroll in engineering. Approximately 80,000 of them will graduate as new engineers in four or five years. They then join about 1,500,000 engineers already at work.

That sounds like a lot. It is. In fact, there are more engineers than there are doctors and lawyers combined. Because the profession is so big—only educators, taken as a group, are more numerous—more than 30,000 retire from engineering each year. That means the profession of engineering doesn't have to grow very fast to provide enough jobs for all the new entrants.

Of the new engineers, almost 50,000 have a bachelor of science degree in engineering. The BS takes at least four years to earn. Some colleges require five years. And about a quarter of all engineering students enrolled in a four-year program actually take at least an extra semester to complete it. Engineering is that tough.

Each year 20,000 graduates earn a master of science degree in engineering. The MS takes either one or two years of work, depending on the exact engineering discipline.

Related Professions

Engineers with these degrees are "individuals who use their professional skills to translate the research theories of scientists into useful products and services for humankind." That's the definition used by most employment specialists.

As high technology becomes more common in everyday life, however, related fields also are growing. In many ways, professionals in those fields resemble engineers in their education, job skills, and even income.

Engineering Technologists

Most closely related to engineers are the "engineering technologists." Most hold four-year degrees, with titles like "bachelors of science in engineering technology," or BSET for short. BSET students tend to need fewer math courses than regular engineers, but take more laboratory courses. BSET graduates with four-year degrees often find themselves working alongside engineers at construction sites or in teams installing large computer systems or telecommunications networks.

At some colleges, courses in management, accounting, or business law can be substituted for math and theoretical subjects that "normal" engineers would take. BSET graduates from such courses often go on to get an MBA (masters in business administration) or an MS in management. Or they might go on to run their own companies, constructing houses, warehouses, and small office buildings.

Because they lack theoretical coursework that most engineers take, however, they usually do not work at the frontiers of knowledge, or in designing super-complex projects, like large dams and bridges.

The gap between engineers and engineering technologists is largest in the fastest-moving fields, like computer science. It is smallest in fields that place a premium on experience and nontheoretical practice, like civil engineering, which consists mainly of designing and building public works, such as roads.

Engineering Technicians

Technicians are usually further removed from engineering. Most have a two-year associate's degree in an engineering technology program, plus formal on-job training.

Technicians perform lab tests—simple and complex—and maintain high technology equipment. That's everything from satellite dishes to modern ventilation systems; from factory robots to the heat-resistant tiles on the space shuttle.

What's in a Name?

Don't confuse any of the professions we have just discussed with jobs that have "engineer" in their title, but do not require the technical expertise learned in a college program. Such titles include "stationary engineers" (who operate and maintain engines and other mechanical equipment), "locomotive engineers" (who operate trains), and "sanitary engineers" (when the title is given to people who are janitors or who collect garbage). Actually, sanitary engineering is a subspecialty of civil engineering. Some sanitary engineers do design pollution-control plants and sewage systems. But, as you can see, the term "engineer" is not always used correctly.

Changing Times

In the past three years or so, growing availability of personal computers—and the headline-making growth in the computer industry—has stimulated a surge in computer-related engineering enrollment. Electrical engineering, and its close cousin, computer engineering, have been particularly favored. Graduates design electrical equipment, including computers, disk drives, and so forth.

Computer engineering shouldn't be confused with computer science. Computer science graduates tend to work with software rather than hardware. They develop new programming languages (BASIC and COBOL are two old computer languages), and create new ways to use old languages—for graphics, or to help robots "see," or to help companies run their businesses.

Computer-related fields are constantly changing, however, and the differences between computer science and computer engineering can sometimes be narrow enough so that people with either degree work on the same project—designing a new electronic chip, for instance.

Where They Live

Wherever people live and work, there are engineers. That's because engineers are necessary to build homes and factories, to design and service products, to develop farmland, and to run cities' water systems, sewers, telephones, and electrical generators.

In fact, one out of every 50 American families has a member who is an engineer. It is hardly surprising, then, that a third of all engineers live in just three highly populated states—California, New York, and Texas.

While there are some major centers where engineers tend to congregate—Boston's Route 128, California's Silicon Valley, North Carolina's Research Triangle Park, to name a few—the majority of engineers do *not* work in such cradles of technology. Thus, they end up with nonengineer neighbors and friends, too.

The following descriptions are composites of real people working in engineering across the country and abroad.

→

Careers in Engineering, Part II: Profiles

New Jobs in the Factory

Jill Michaels

"My father worked in an automobile assembly plant until he retired last year," Jill Michaels relates. "He says he sent me to college so that I wouldn't have to work in a factory too." Jill laughs, because she is speaking from the floor of a factory. She works in a highly automated plant in Connecticut that makes cooling fans for electronic equipment. The little fans must operate reliably, otherwise the equipment that they protect—photocopying machines, personal computers, dishwashers, and so forth—can be damaged from overheating.

Her company's products are so good that even the Japanese buy them. Four years ago, when Jill joined the staff as a mechanical engineer straight out of college with a bachelor's degree, the plant was just beginning to become automated.

"We had to do it, even though some of the new machines were more expensive than the workers they replaced," says Jill. "Our customers demanded higher quality than human workers could provide. A machine does things the same way all the time."

It sounds harsh. But in Jill's plant, everything worked out fine. The company's market expanded so fast that no workers were actually laid off as machines were phased in.

"We make 40,000 fans a week now with 300 workers," says Jill. "Those 300 workers used to make only 10,000 fans per week a few years ago."

Jill helped choose some of the new equipment that was installed. "I worked for a plant manager who had a great deal of practical knowledge, but no formal training in the new manufacturing technologies. He taught me that some things I learned in textbooks were not practical on the plant floor. I taught him that automation could really work, with his help."

Jill also found herself working with some of the engineers who had initially designed the fans. The designs were modified slightly to take advantage of the new machines. "The fan motors had magnetic coils made from little stacks of metal plates. The metal was stamped out from large sheets, and each edge was rounded because otherwise the raw edges would cut workers' hands, she said.

"Now a robot assembles the plates, and we don't have to spend money smoothing the edges—which are hidden once the fan is fully assembled."

Some of the fastening screws were relocated by the designers, to make it easier for specially built machines to tighten them.

Jill's boss says she can hire a new engineering graduate this year to help her. And she and her boss both are taking extra courses at a nearby university. Jill is adding electrical engineering skills to her BS in mechanical engineering. She's also learning about new fiber-composite materials that might be used instead of metal in fan blades.

From a starting salary of $23,000, Jill now makes more than $33,000 for her efforts.

That's as much as her father made during his last year on the assembly line!

Sam MacNamee

The jetliner climbs away from Bangkok's airport. Sam MacNamee puts his head back and relaxes—reflecting on his seven years as a chemical engineer. He'll have plenty of time to think about it. The Boeing 747 will fly first to Tokyo, then on across the Pacific for 13 hours to Los Angeles and home.

"When I finished my master's degree in chemical engineering in 1978, I headed for southern California, home base for many large engineering firms that design and build chemical plants for companies in the United States and abroad," says Sam. His master's degree allowed him to specialize in corrosion problems, after a more general BS in chemical engineering.

Most chemical plants use petrochemicals—materials derived from oil—and turn those materials into fertilizers, plastics, dyes, medicines, and numerous other products. All through the '70s, those materials rose in price. And the sources of raw materials changed, too, as more and more countries outside the Middle East began pumping oil from new wells.

"Most of the new sources provided oil with higher sulfur content than does the Middle East," Sam says. The extra sulfur, and other impurities, caused more corrosion problems than might otherwise be expected in chemical plants.

As a result, Sam kept busy even in 1982, when worldwide recession and an oversupply of many chemical products caused a lot of engineers in this field to lose their jobs.

The best jobs available were all overseas. That was all right with Sam, because he wasn't married, and did not have any family responsibilities. Big chemical plants, and many other big engineering projects abroad, like dams and railroads, usually are built far from big cities. Thus, the living quarters usually aren't as comfortable as those at home in the U.S.

"Engineers like me often change employers once or twice in seven years," Sam says, "but I was happy just to have a good job during the bad times, so I took some assignments abroad that weren't exactly glamorous." He was able to save about half his $40,000 annual salary, too, because the company subsidized his living expenses.

One reward was Bangkok, where Sam went to build an addition to a large chemical plant. "Thailand is expanding its industry very fast, and it's not a bad place to raise a family for the first few years," Sam mused. He is returning home to Los Angeles to marry, then he and his wife will fly back to the Far East to work.

With seven years' experience, Sam will manage a small group of engineers, technologists, and technicians installing new equipment.

After Bangkok? Sam expects to hone his emerging management skills with bigger projects back in the United States. He also expects to take more management courses. Within about five years, he should be doing almost no design and installation work, but will be entirely a manager. He expects to make more than $60,000 per year once that happens. —

Photo: Courtesy Shell Oil Company

Working Abroad

Photo: Courtesy Hewlett-Packard

The Chips Are Down

Jan Tunnelle

Jan works for a small software company that specializes in creating exciting computer graphics. "An advertising agency might want computer-generated graphics to demonstrate a new product at a trade show. Or a guy with an idea for a game might need help turning it into a computer program. Our company supplies the graphics that make it possible.

"The whole business didn't exist five years ago, when I started college, so I hardly was focusing on it as a career," she says. This field, computer graphics, now employs between 10,000 and 20,000 programmers.

Many of these programmers have only a high school degree. Why go to college, then? "High schools mainly teach programming in BASIC and in Pascal, but advanced graphics are created, more and more, in the C programming language," says Jan.

After graduating in 1984 with a BS degree in computer science, Jan accepted a job with a company she had worked for during her last year in college. "Because they knew me, and because I already knew how to use their graphics software 'library,' they started me with a salary of $25,000."

She also was granted the right to buy stock, at a reduced price, in her employer's small company. That's a common benefit in a new, growing organization. "It makes up for the long hours and working through weekends when something goes wrong with a program or when a client needs something in a hurry," she says.

Jan expects to start her own company within four or five years. She wants to use her graphics skills to design educational programs for people with exceptionally poor eyesight. "They have trouble reading a regular book, but we can use the computer screen to show a blow-up of printed images," she says.

Careers in Engineering, Part III: New Directions/ Current Data

Engineering Market Is Strong

Engineering as a whole remains one of the most recession-proof of all professions. After relatively bad years in 1982 and 1983, the demand improved faster than for other college graduates as the economy improved in 1984 and 1985.

Engineers, who make up less than 10 percent of each year's graduating college seniors, routinely garner more than half of all job offers, according to the College Placement Council.

For 1985, engineers may get 60 percent of all the offers, thanks to strong demand by the aerospace industry. Unemployment in engineering stands at about two percent, compared to five percent for all white-collar workers, and closer to eight percent for all adults.

But engineering is really not one profession. Instead, it can describe many different fields. And economic trends affect each field differently. When the federal government spends money on highways and sewage treatment plants, civil engineers benefit. When it wants to emphasize military spending, as it does today, aeronautical engineers find new opportunities.

An aeronautical engineer can't build a skyscraper, and a civil engineer can't build an airplane.

Hottest Branches in Engineering

This year, the hottest specialties are computer science, electrical engineering, and mechanical engineering, according to Peterson's Guides, a publisher of career information for engineers.

The design and manufacture of electronic products now accounts for 2.6 million jobs in the United States; in 1984 it moved ahead of vehicle manufacturing to become the largest source of industrial employment.

Industrial trade associations in the electronics and aerospace fields predict that growth for electrical engineers in general and computer specialists in particular will be stronger than for other engineering fields.

The studies are suspect, however, because they are self-serving. For instance, the more computer scientists there are, the more likely that salaries will be held in check. Therefore, industry may try to encourage more students to study computer science.

In fact, a 1984 study of the nation's 500 largest industrial companies shows that programmers are no longer in great demand. The study, by the Diebold Group, a New York City-based technology consulting firm, shows that telecommunications skills were most needed. Electrical engineers, computer engineers, and computer science majors can all obtain such skills on the way to their degree. But the type of coursework varies from college to college, even when the degrees have the same name.

Starting salary offers for 1985 graduates with a four-year engineering degree were close to $30,000 a year. They have not risen much in the past two years. But then again, neither has the cost of living.

Who Do Employers Hire?

For the past decade, employers have tended to prefer graduates with "general" undergraduate degrees. That is, they shy away from overspecialization, preferring to train new employees themselves for specific tasks. General degrees have titles like "chemical engineering" rather than "chemical instrumentation engineering," or "mechanical engineering" instead of "heating and ventilating engineering."

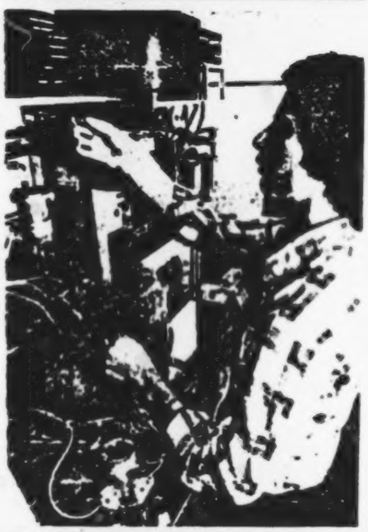
Petroleum engineering did particularly well in the past decade. But demand is now tapering off, as it is for mining engineers (mines and oil fields are being closed down due to lack of demand).

Employers don't mind specialization in master's degree coursework, especially if the graduate has worked a few years before going back to school to get the MS. By then, employers assume, graduates know what they might like to do in the field.

There's a big increase in engineers getting a BS in a general field like aeronautical, chemical, civil, or mechanical engineering, and then topping the degree off with a master's in a computer-related field. Such graduates tend to perform well on the job, because they know more about business needs than would a person with only a computer background.

Technologists Reap Better Yields

Holders of a four-year technologists' degree earn about as much as BS engineers, if they work for a large utility. Technologists in civil



Photos (unless otherwise noted): Courtesy AT&T Bell Laboratories

and mechanical fields do almost as well financially, on the average, as their engineering counterparts. The technologists in those fields tend to work for smaller companies doing less sophisticated work. Thus, starting salaries are lower for them. But the best technologists are more likely to start their own companies, particularly in construction.

Electrical engineering technology degrees are becoming more and more useful on plant floors, to deal with robots and other automated equipment. These technologists also help service the increasing number of computers and other electrical equipment used in offices and in the home. But their lower level of theoretical design knowledge hurts them when competing for jobs in computer-company labs.

Stepping Up

Two-year associates' degrees can be a good stepping-stone to a four-year engineering degree, after the graduate gains some work experience. That's a good career path to consider when finances make an engineering degree impossible now, or if high school did not offer enough math preparation.

It usually takes at least three years of extra study on top of an associate's degree (or on top of two years of liberal arts) to gain a BS in engineering.

Where Engineers Study

There are about 300 colleges and universities in the United States that offer engineering degrees. Unlike most professional programs, the engineering programs of many state-supported schools have reputations that are as good as those of private schools. Texas A&M has the largest engineering college of all.

Other particularly well-regarded state schools are Georgia Tech in Atlanta, Virginia Polytechnic Institute and State University in Blacksburg, the University of Illinois at Urbana/Champaign, the University of California at Los Angeles, and the University of Colorado. Employers don't offer significantly higher salaries to engineering graduates of "name" schools, like MIT and Stanford, as is true for many other grads.

Programs are accredited by the *Accreditation Board for Engineering and Technology* (ABET). ABET is unusual, in that engineering colleges as a whole are not accredited. It is not uncommon to find a college with some ABET-accredited curricula, and some without accreditation.

Beware a college or university that has *no* ABET-accredited programs, or none in a broad field of study like computer engineering. It indicates that the program is either quite new (no program gains final ABET approval until it produces graduates), or not up to standards.

When in doubt, ask local employers of recent grads. And check with the campus placement office to see which companies are recruiting.

The New Engineers

As late as 1970, only 10,000 women were engineers. They made up one percent of all engineers at that time. The number is now 45,000—more than three percent of all engineers. Women make up roughly one out of every seven new graduates. Many engineering schools are now 25 percent female.

Growth has not been as great among minority graduates in engineering. From less than one percent of all engineers in 1970, blacks now make up a little over two percent. The growth does continue, however, because the engineering profession started from the ground up—helping to improve math skills in lower grades, and therefore to increase the pool of qualified applicants.

Unfortunately, high college costs and a slackening of financial aid threatens the pool more than does a shortage of skills.

Starting Now...

High school graduates should have at least three years of math—including calculus—and two of a lab science before considering engineering. Knowledge of a computer language is a big plus.

Combined SAT scores of 1200 are a bare minimum for engineering. As might be expected, engineering candidates score much higher in math than do typical college entrants. But engineering students also average higher on the SAT verbal portion as well!

. . . And Tomorrow?

What is the outlook for the engineers of the '90s? Although no official source predicts a downturn, a few engineering-watchers are flashing caution signs.

Some say the electronic and semiconductor industries have slumped—and will demand fewer electrical and electronics engineers.

But others point toward "Star Wars" and similar military projects and predict sunny skies—for aeronautical engineers in particular.

Overall, engineering continues to look strong. But, as J. Paul Getty is reported to have said when asked to predict the future course of the stock market: "It will fluctuate."

And so it goes for engineering, too. ☐

For More Information

JETS, Inc.
c/o United Engineering Center
345 East 47th Street
New York, NY 10017

Pamphlets: EC-90 series "Engineering Technology," includes: 90AeroET—"Aeronautical Engineering Technology," 90ChET—"Chemical Engineering Technology," 90EET—"Electronic Engineering Technology," 90ET—"Engineering Technology," 90IET—"Industrial Engineering Technology," single copies of each free; use proper designation for the series requested. EC-70 series "Engineering," includes: 70Aero—"Aerospace Engineering," 70AgE—"Agricultural Engineering," 70AE—"Automotive Engineering," 70BioE—"Biomedical Engineering," 70ChE—"Chemical Engineering," 70E—"Engineering," 70EE—"Electrical and Electronic Engineering," 70IE—"Industrial Engineering," 70Mfg—"Manufacturing Engineering," 70ME—"Mechanical Engineering," 70Met—"Metallurgical Engineering," 70Mine—"Mining and Mineral Engineering," 70NE—"Nuclear Engineering," 70PlasE—"Plastics Engineering," single copies of each free; use proper designation for the series requested.

AB-20—"Accredited Programs Leading to Degrees in Engineering, 1984" and AB-21—"Accredited Programs Leading to Degrees in Engineering Technology, 1984," single copies of each $2 prepaid.

Educational Services
Institute of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08854

Booklet: "Careers in the Electrical, Electronics, and Computer Engineering Fields," single copy free.

Institute of Industrial Engineers
25 Technology Park/Atlanta
Norcross, GA 30092

Pamphlet: "Planning Your Career as an IE," single copy free.

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017

Pamphlet: "Is Civil Engineering for You?" Single copy free.

American Institute of Chemical Engineers
345 East 47th Street
New York, NY 10017

Pamphlet: "Careers in Chemical Engineering" and "Why Be a Chemical Engineer," single copies of each free; send a self-addressed, stamped, long, white envelope.

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

Booklet: "A Career for the Future," includes engineering education guidelines and a list of accredited programs; Pamphlet: "What Is a Mechanical Engineer?" Single copies of each free.

Book:

Engineering, Science, and Computer Jobs 1985 edited by Christopher Billy; Peterson's Guides, P.O. Box 2123, Princeton, NJ 08540; 1985; paperback; $16.95, includes postage and handling.

Photo: Courtesy Shell Oil Company

APPENDIX D

LIBRARY BOOK ORDER

1. Bailey, Robert L., Disciplined Creativity for Engineers, Ann Arbor Science, Butterworth Publishers, 80 Montvale Ave., Stoneham, MA 02180
2. Bame, E. Allen & Cummings, Paul, Exploring Technology, Davis Publications Inc., 1980
3. Beakley, George C., Careers in Engineering and Technology, Third Edition, Macmillan Publishing Company, NY 1984
4. Blotter, Thomas P., Introduction to Engineering, John Wiley & Sons, 1 Wiley Drive, Somerset, NJ 08873. (201) 469-4400
5. Furnas, C. C. & McCarthy, J., The Engineer, Time-Life Books, New York 1971
6. Jacobs, James A. & Kilduff, Thomas F., Engineering Materials Technology, Prentice Hall, Inc., Inglewood Cliff, NJ 07632, 1985. (201) 592-3242
7. Kemper, John Dustin, Introduction to the Engineering Profession, Holt, Rinehart and Winston, 1985
8. Krick, Edward V., An Introduction to Engineering--Concepts, Methods and Issues, John Wiley, 1976
9. Morris, George E., Engineering--A Decision-Making Process, Houghton Mifflin, 1977
10. Red, W. Edward, Careers in Engineering and Technology, Brooks/Cole Division, Wadsworth, Inc., 1983
11. Red, W. Edward & Mooring, Benjamin, Engineering--Fundamentals of Problem Solving, Brooks/Cole Division, Wadsworth, Inc., 1983
12. Schwaller, Anthony E., Energy Technology: Sources of Power, Davis Publications, Inc., 1980
13. Unified Technical Concepts--Physics for Technicians, Second Edition, The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710, 1984

INTROENG:1
PE4

APPENDIX E

ENGINEERING PROJECTS AND CASE STUDIES

I. Case Studies

Engineering Case Library. A 55 page catalog of case studies designed for classroom use in various engineering disciplines. Send $2 for catalog to: American Society for Engineering Education, 11 DuPont Circle, N.W., Suite 200, Washington, DC 20036. Also request publications list.

10 Cases in Engineering Design by H. O. Fuchs and R. F. Steidel, Jr., Longman, 1973.

Engineers at Work: A Casebook by K. H. Vesper, Houghton Mifflin Co., 1975.

II. Space Projects

NASA Tech Briefs, 41 E. 42nd St., Suite 921, New York, NY 10017.
Solar Sail Project. A spacecraft under development for future investigations of solar system. Write for more information to the Secretary, D-130, World Space Foundation, P.O. Box Y, South Pasadena, CA 91030.

III. Steel or Material Projects

"Making Steel With Money." Free filmstrip from American Iron and Steel Inst. 1000 16th St., N.W., Washington, DC 20036.

IV. Energy Projects

Teacher's Kit on Nuclear Energy. Free kit from Atomic Industrial Forum, Inc., 7101 Wisconsin Ave., Bethesda, MD 20814-4891.
Technical Courses below available from The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710:
    Energy Audits. ISBN 1-55502-058-5.
    Energy Production Systems. ISBN 1-55502-056-9.
    Introduction to Lasers. ISBN 1-55502-019-4.

V. Civil or Construction Projects

McCullough, David. The Great Bridge. ISBN #0-671-45711X. Simon & Schuster. New York, 1983.
McCullough, David. The Path Between the Seas. Simon & Schuster, New York, 1977
Soo Locks, Sault Ste. Marie, Michigan, US Army Corps of Engineers, Detroit District

VI. Laser Projects

Kettlekamp, Larry. Lasers, The Miracle of Light. New York: William Morrow & Co., Inc. 1979.

APPENDIX F

FORMULAS AND CHARTS FOR STUDENT REFERENCE

I. Alkazin materials from notebook

II. Charts and formulas to add here for reference (see Bob in NPN)

III. Periodic Tables

IV. Conversion Charts

INTROENG:1
PE4

PERIODIC CHART OF THE ELEMENTS

THE SYMBOL. Shown in the middle of each block directly below the name of the element. The color used indicates the physical state of the element under ordinary conditions: black for solids, green for liquids and blue for gases.

THE ATOMIC WEIGHT. Directly below the symbol for each element the atomic weight is shown in black. The values are taken from the official Report on Atomic Weights Cf. J. Amer. Chem. Soc. 84, 4193 (1962). For elements not listed in the Report the mass number of the longest lived isotope is shown in brackets.

THE ATOMIC NUMBER. Shown in red in the upper left hand corner.

ELECTRONIC CONFIGURATION. Shown at the upper right as a group of black numerals. When read downward they indicate the number of electrons normally found in successive energy levels.

NON METALS

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1	1 H 1.00797																	2 He 4.0026
2	3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
3	11 Na 22.9898	12 Mg 24.312											13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
4	19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99.)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
6	55 Cs 132.905	56 Ba 137.34	57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.05	89 Ac 227.04															

* Lanthanide Series →	58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
‡ Actinide Series →	90 Th 232.038	91 Pa 231.05	92 U 238.03	93 Np 237.06	94 Pu (242)	95 Am (243)	96 Cm (245)	97 Bk (249)	98 Cf (249)	99 Es (253)	100 Fm (255)	101 Md (256)	102 No (253)	103 Lr (257)

FISHER SCIENTIFIC COMPANY
EDUCATIONAL MATERIALS DIVISION
Chicago, Illinois [illegible]

PHYSICAL PROPERTIES OF COMMON METALS & ALLOYS

Metal or Alloy	Density at 20°C (grams per cm^3)	Specific Heat at 20°C	Melting Point Centigrade	Coefficient Linear Expansion at 20°C (per C° x 10^{-6})	Resistivity at 20°C (micro-ohms per cm)
Aluminum	2.7	0.21	659	26	2.82
Brass	8.6	0.092	900	19	7
Cadmium	8.65	.055	321	28.8	7.62
Chromel 180	8.95	.092	1100	16.1	29.8
Copper	8.9	0.091	1083	17	1.72
German Silver	8.4	0.094	1100	18.4	33
Gold	19.3	.031	1063	14.3	2.44
Iron	7.8	0.115	1535	11	10
Lead	11.3	0.031	327	29	22
Magnesium	1.74	.245	651	26.0	4.6
Manganin	8.4	——	910	18.7	44.0
Nichrome Alloy	8.2	——	1500	13.7	100
Platinum	21.4	.032	1755	8.8	10.0
Silver	10.5	0.056	960	18.8	1.59
Steel	7.8	0.107	1510	12.0	10-70
Tungsten	18.7	.034	3400	4.3	5.5
Zinc	7.1	0.092	419	26.3	5.8

PHYSICAL PROPERTIES OF COMMON LIQUIDS

Liquid	Density at 20°C (grams per ml)	Specific Heat 15°C (cal/g-C°)	Boiling Point at 760mm Hg (°C)	Coefficient of Volume Expansion at 20°C (per C° x 10^{-3})	Index of Refraction for Sodium Light
Acetic Acid	1.05	.468	118.1	1.071	1.37
Acetone	.7908	0.52	56.2	1.49	1.36
Alcohol, Ethyl	.789	0.56	78.5	1.12	1.36
Alcohol, Methyl	.793	0.59	64.96	1.20	1.33
Alcohol, N-Propyl	.7796	.586	97.2	.956	1.39
Aniline	1.022	.488	184.4	.858	1.58
Benzene	.879	.406	80.1	1.24	1.50
Carbon Disulfide	1.263	——	45.0	1.15	1.63
Carbon Tetrachloride	1.595	0.20	76.8	1.24	1.4664
Chloroform	1.50	.234	61.3	1.27	1.4433
Ether, Diethyl	.714	0.54	34.6	1.66	1.35
Glycerol	1.26	0.56	290	0.51	1.47
Mercury	13.6	0.033	357	0.182	1.62
Toluene	.867	.395	110.6	1.099	1.4961

PHYSICAL PROPERTIES OF BALSA WOOD

AS COMPILED BY

ASCE (AMERICAN SOCIETY OF CIVIL ENGINEERS)

SPECIFIC GRAVITY - .13

MODULUS OF ELASTICITY - 364,000 #/SQ. IN.

MODULUS OF RUPTURE - 25,400 #/SQ. IN.

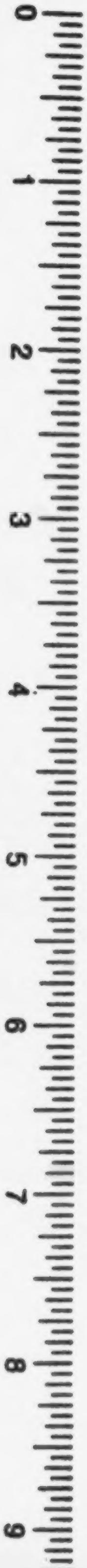
FLEXURE - 24,819 #/SQ. IN.

COMPRESSION - 1138 #/SQ. IN.

TENSION - 700 #/SQ. IN.

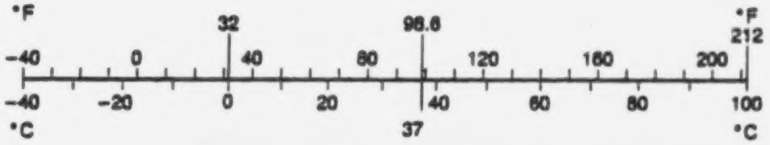
BEARING - 1586 #/SQ. IN

ETRIC CONVERSION FACTORS (Approximate)



Conversions TO Metric Measures

	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH	in	inches	2.54	centimeters	cm
	ft	feet	30.48	centimeters	cm
	yd	yards	0.9	meters	m
	mi	miles	1.6	kilometers	km
AREA	in^2	square inches	6.5	square centimeters	cm^2
	ft^2	square feet	0.09	square meters	m^2
	yd^2	square yards	0.8	square meters	m^2
	mi^2	square miles	2.6	square kilometers	km^2
		acres	0.4	hectares	ha
MASS (Weight)	oz	ounces	28	grams	g
	lb	pounds	0.45	kilograms	kg
		short tons (2000 lb)	0.9	tonnes	t
VOLUME	tsp	teaspoons	5	milliliters	ml
	Tbsp	tablespoons	15	milliliters	ml
	fl oz	fluid ounces	30	milliliters	ml
	c	cups	0.24	liters	l
	pt	pints	0.47	liters	l
	qt	quarts	0.95	liters	l
	gal	gallons	3.8	liters	l
	ft^3	cubic feet	0.03	cubic meters	m^3
	yd^3	cubic yards	0.76	cubic meters	m^3
TEMP. $°C = \frac{5}{9}(°F - 32)$	°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Conversions FROM Metric Measures

	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH	mm	millimeters	0.04	inches	in
	cm	centimeters	0.4	inches	in
	m	meters	3.3	feet	ft
	m	meters	1.1	yards	yd
	km	kilometers	0.6	miles	mi
AREA	cm^2	square centimeters	0.16	square inches	in^2
	m^2	square meters	1.2	square yards	yd^2
	km^2	square kilometers	0.4	square miles	mi^2
	ha	hectares (10,000 m^2)	2.5	acres	
MASS (Weight)	g	grams	0.035	ounces	oz
	kg	kilograms	2.2	pounds	lb
	t	tonnes (1000 kg)	1.1	short tons	
VOLUME	ml	milliliters	0.03	fluid ounces	fl oz
	l	liters	2.1	pints	pt
	l	liters	1.06	quarts	qt
	l	liters	0.26	gallons	gal
	m^3	cubic meters	35	cubic feet	ft^3
	m^3	cubic meters	1.3	cubic yards	yd^3
TEMP. $°F = \frac{9}{5}(°C + 32)$	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

Career opportunities, continuing education, adventure. It all adds up to NAVY.

fixes and symbols to form decimal multiples and/or multiples.

Power of Ten	E Notation	Decimal Equivalent	Prefix	Phonic	Symbol
10^{12}	E+12	1 000 000 000 000	tera	ter'a	T
10^{9}	E+09	1 000 000 000	giga	ji'ga	G
10^{6}	E+06	1 000 000	mega	meg'a	M
10^{3}	E+03	1 000	kilo	kil'o	k
10^{2}	E+02	100	hecto	hek'to	h
10	E+01	10	deka	dek'a	da
10^{-1}	E−01	0.1	deci	des'i	d
10^{-2}	E−02	0.01	centi	sen'ti	c
10^{-3}	E−03	0.001	milli	mil'i	m
10^{-6}	E−06	0.000 001	micro	mi'kro	μ
10^{-9}	E−09	0.000 000 001	nano	nan'o	n
10^{-12}	E−12	0.000 000 000 001	pico	pe'ko	p
10^{-15}	E−15	0.000 000 000 000 001	femto	fem'to	f
10^{-18}	E−18	0.000 000 000 000 000 001	atto	at'to	a

Coefficient of Friction: $\mu = \frac{F}{N}$

μ = coefficient of friction
F = force of friction N = force normal to surface

Velocity: $v_{av} = \frac{d}{t}$

v_{av} = average velocity
d = distance traveled t = elapsed time

Acceleration: $a = \frac{v_f - v_i}{t}$

a = acceleration v_i = initial velocity
v_f = final velocity t = elapsed time

wton's 2nd Law of Motion: $F = m \cdot a$
= force m = mass a = acceleration

Law of Universal Gravitation: $F = G\frac{m_1 \cdot m_2}{d^2}$

F = force of attraction $m_1 \cdot m_2$ = product of masses
G = gravitational constant d = distance between their centers

Centripetal Force: $F = \frac{m \cdot v^2}{r}$

F = centripetal force
m = mass v = velocity r = radius of path

Pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$

T = period l = length g = acceleration of gravity

Work: $W = F \cdot d$
W = work F = force d = distance

Mechanical Advantage: IMA = $\frac{F_E \cdot d}{F_R \cdot d}$ AMA = $\frac{F_R}{F_E}$

IMA = ideal mechanical advantage   AMA = actual mechanical advantage
F_E = effort force
F_R = resistance force d = distance

Mechanical Equivalent of Heat: $W = J \cdot Q$
W = work J = mechanical equivalent of heat Q = heat

Kinetic Energy: $K = \frac{1}{2} m \cdot v^2$
K = kinetic energy m = mass v = velocity

Potential Energy: $V = m \cdot g \cdot h$
V = potential energy g = acceleration of gravity
m = mass h = vertical distance (height)

Relationship between Mass and Energy: $E = m \cdot c^2$
E = energy m = mass c = velocity of light

Wave Formula: $v = f \cdot \lambda$
v = wave speed f = frequency λ = wave length

Uniformly Illuminated Surface: $E = \frac{\Phi}{A}$
E = illumination
Φ = luminous flux   A = uniformly illuminated area

Images in Mirrors and Lenses: $\frac{S_o}{S_i} = \frac{D_o}{D_i}$
S_o = object size D_o = object distance
S_i = image size D_i = image distance

Focal Length of Mirrors and Lenses: $\frac{1}{f} = \frac{1}{D_o} + \frac{1}{D_i}$
f = focal length
D_o = object distance D_i = image distance

Index of Refraction: $n = \frac{\sin \Theta_i}{\sin \Theta_r}$
n = index of refraction
Θ_i = angle of incidence Θ_r = angle of refraction

Electric Current: $I = \frac{q}{t}$

I = current q = quantity of charge t = time

Coulomb's Law of Electrostatics: $F = k\frac{q_1 \cdot q_2}{d^2}$
F = force between two charges
k = proportionality constant
$q_1 \cdot q_2$ = product of charges
d = distance separating charges

Capacitance of a Capacitor: $C = \frac{q}{V}$
C = capacitance of a capacitor
V = potential difference between plates
q = charge on either plate

Ohm's Law of Resistance: $E = I \cdot R$
E = emf of source I = current in the circuit
R = resistance of the circuit

Joule's Law: $Q = I^2 \cdot R \cdot t$
Q = heat energy I = current R = resistance t = time

Faraday's Law of Electrolysis: $m = z \cdot I \cdot t$
m = mass z = electrochemical equivalent
I = current t = time

Induced emf: Coil in a Magnetic Field: $E = -N\frac{\Delta\Phi}{\Delta t}$
E = induced emf N = number of turns
$\Delta\Phi/\Delta t$ = the change in flux linkage in a given interval of time

Induced emf: Conductor in a Magnetic Field: $E = B \cdot l \cdot v$
E = induced emf B = flux density of the magnetic field
l = length of conductor
v = velocity of conductor across magnetic field

Instantaneous Voltage: $e = E_{max} \sin \Theta$
e = instantaneous voltage
E_{max} = maximum voltage
Θ = angle between the plane of the conducting loop and the perpendicular to the magnetic flux (displacement angle)

Instantaneous Current: $i = I_{max} \sin \Theta$
i = instantaneous current
I_{max} = maximum current
Θ = displacement angle

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Mechanical Equivalent of Heat is the work required to produce a unit quantity of heat.

0.427 kilogram-meter (kg-m) = 1 calorie

$$\frac{\text{Work}}{\text{mechanical equivalent of heat}} = \text{heat}$$

VALENCES SHOWN BY COMMON RADICALS

Name	Symbol	Valence
Acetate	$C_2H_3O_2$	—1
Bicarbonate	HCO_3	—1
Bisulfate	HSO_4	—1
Carbonate	CO_3	—2
Chlorate	ClO_3	—1
Chromate	CrO_4	—2
Ferricyanide	$Fe(CN)_6$	—3
Ferrocyanide	$Fe(CN)_6$	—4
Hypochlorite	ClO	—1
Nitrate	NO_3	—1
Nitrite	NO_2	—1
Permanganate	MnO_4	—1
Phosphate	PO_4	—3
Sulphate	SO_4	—2
Sulphite	SO_3	—2

EXPONENTIAL NUMBERS

Multiplication by a positive power of 10 corresponds to moving the decimal point to the right; multiplication by a negative power of 10 corresponds to moving the decimal point to the left.

1.33×10^4 is 13,300

1.33×10^{-4} is 0.000133

Numbers expressed with powers of 10 cannot be added or subtracted directly unless the powers of 10 are the same.

$1.23 \times 10^4 + 1.23 \times 10^5 =$
$1.23 \times 10^4 + 12.3 \times 10^4 = 13.5 \times 10^4$

$1.23 \times 10^{-4} - 1.23 \times 10^{-5} =$
$1.23 \times 10^{-4} - 0.123 \times 10^{-4} = 1.11 \times 10^{-4}$

When the powers of 10 are multiplied, exponents are added; when divided, exponents are subtracted.

$(1.23 \times 10^4) \times (1.23 \times 10^5) =$
$(1.23 \times 1.23) \times (10^4 \times 10^5) = 1.51 \times 10^9$

$$\frac{1.23 \times 10^{-4}}{1.23 \times 10^{-5}} = \frac{1.23}{1.23} \times \frac{10^{-4}}{10^{-5}} = 1.00 \times 10$$

SOME ACID—BASE INDICATORS

	Color Change	
Indicator	Acid	Basic
Alizarin Yellow	Yellow	Red
Bromocresol Green	Yellow	Blue
Litmus	Red	Blue
Methyl Orange	Red	Yellow
Methyl Red	Red	Yellow
Phenolphthalein	Colorless	Red
Thymol Blue	Red	Yellow

PRESSURES AND DENSITIES

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

1 column of water 1 foot deep = 62.4 pounds per square foot, or 0.433 pounds per square inch. 1 column of water 1 centimeter deep = 1 gram per square centimeter.

Specific Gravity = number of times a substance is as heavy as an equal body of water, or Specific gravity (liquid) =

$$\frac{\text{Weight of Liquid}}{\text{weight of equal volume of water}}$$

$$\textbf{Density} = \frac{\text{Weight}}{\text{Volume}}$$

Pressure = depth × density, or force per unit area. An increase in pressure is transmitted equally through the liquid.

Specific Gravity (Solid) =

$$\frac{\text{Weight of Body}}{\text{loss of weight in water}}$$

OR Specific Gravity (Solid)

$$\frac{\text{Weight of Body}}{\text{weight of equal volume of water}}$$

One cubic yard of air weighs about 2 pounds. Atmospheric pressure at sea level = about 15 pounds per square inch.

DEFINITIONS: CONCENTRATION OF SOLUTIONS

1) **Mole Fraction:**	The number of moles of solute per unit total moles of solution.
2) **Molarity:**	The number of moles of solute per liter of solution.
3) **Molality:**	The number of moles of solute per 1,000 g. of solvent.
4) **Formality:**	The number of formula weights of solute per liter of solution.
5) **Normality:**	The number of equivalents of solute per liter of solution.

BASIC LAWS AND TABLES

UNITS

Kilo—means one thousand
Centi—means one-hundredth
Milli—means one-thousandth
Micro—means one-millionth
1 **Kilometer** (km) = 1,000 meters = 0.621 mile
1 **Meter** (m) = 100 centimeters = 39.4 inches
1 **Centimeter** (cm) = 10 millimeters (mm) = 0.394 inches
1 **Kilogram** (kg) = 1,000 grams = 2.20 pounds
1 **Gram** (g) = 1,000 milligrams (mg) = 0.0353 ounce.
1 **Liter** (l) = 1,000 milliliters = 1.06 quarts
1 **Milliliter** (ml) = 1.000027 cubic centimeters (cc)
1 **Atomic Mass Unit** = 1.66×10^{-24}g
Avogadro Number = 6.0235×10^{23}

TEMPERATURE MEASUREMENTS

In scientific work, the Centigrade or Celsius (°C) and Kelvin (K) scales are most commonly used. The Kelvin scale is an absolute temperature scale, in which zero degrees ideally represents the lowest attainable temperature.

Comparison of Various Temperature Scales

(°F) Fahrenheit	(K) Kelvin	(°C) Centigrade
212°	373°	100°
32°	273°	0°
−459°	0°	−273°

Fahrenheit—Centigrade: Conversions

C = 5/9 (F − 32)
F = 9/5C + 32

Boyle's Law:

$p_1 \times V_1 = p_2 \times V_2$ at constant temperature. Zero degrees Kelvin is the lowest possible temp.

In Kelvin absolute temperature scale: water boils at 373K, freezes at 273K.

Charles' Law: $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ at constant pressure.

Combination of Charles' and Boyle's Laws:

$$\frac{V_1p_1}{T_1} = \frac{V_2p_2}{T_2}$$

When heated through one degree Centigrade, any gas expands 1/273 of its volume at 0 degrees Centigrade if the pressure remains constant.

One BTU is the heat required to raise the temperature of 1 pound of water through 1 degree Fahrenheit.

One Calorie is the heat required to raise the temperature of 1 gram of water through 1 degree Centigrade.

Specific Heat: heat required to raise the temperature of a unit mass of that substance through 1 degree. If q is total heat and m is mass, $q = m \times s \times (t_2 - t_1)$.

Heat of melting, or heat of fusion, L, is the quantity of heat needed to melt one unit weight of a substance without changing its temperature, or $q = m \times L$

80 calories of heat is required to melt 1 gram of ice without raising its temperature.

Boiling Point of Liquid: that temperature at which the vapor pressure is equal to the pressure above the liquid.

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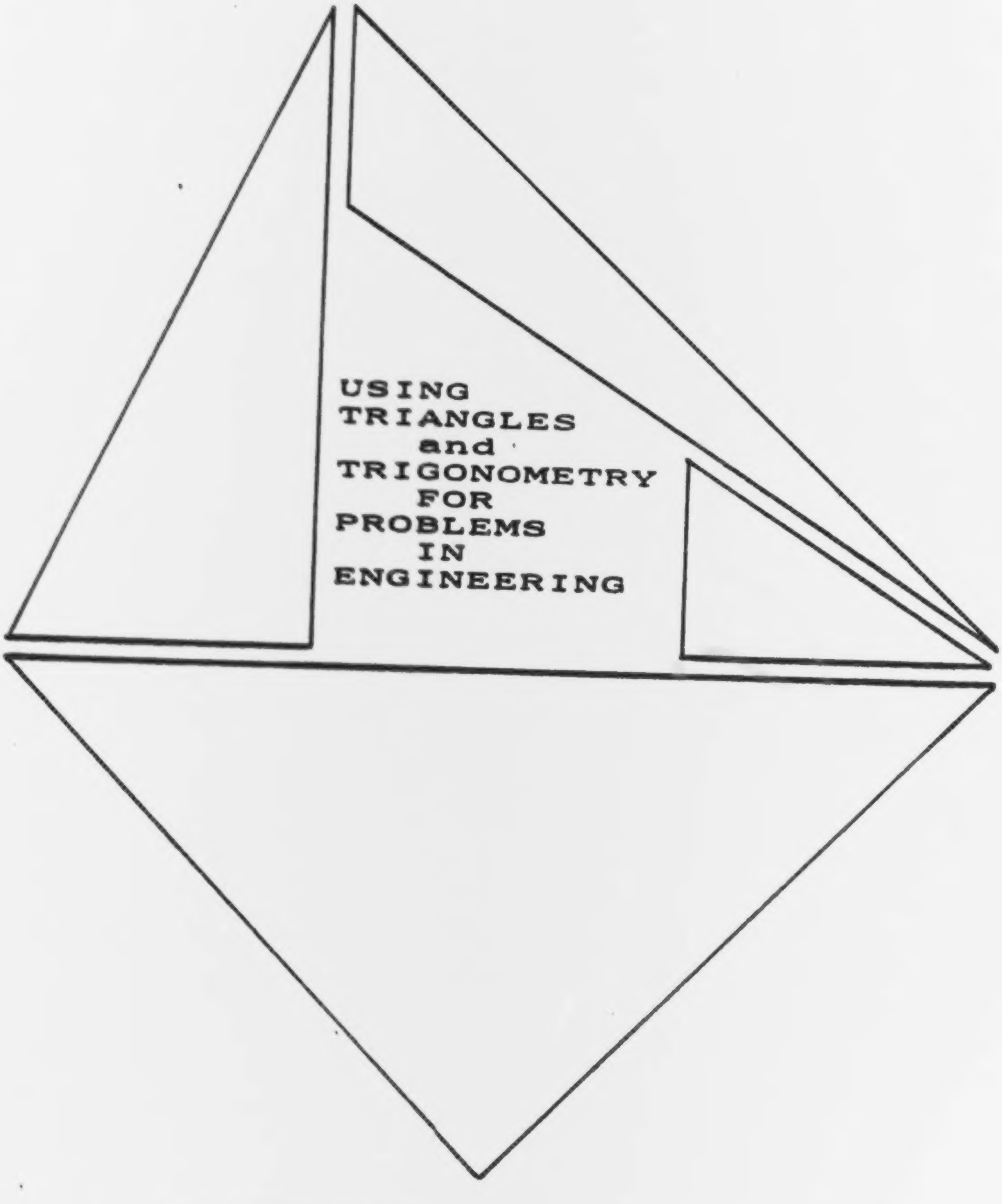


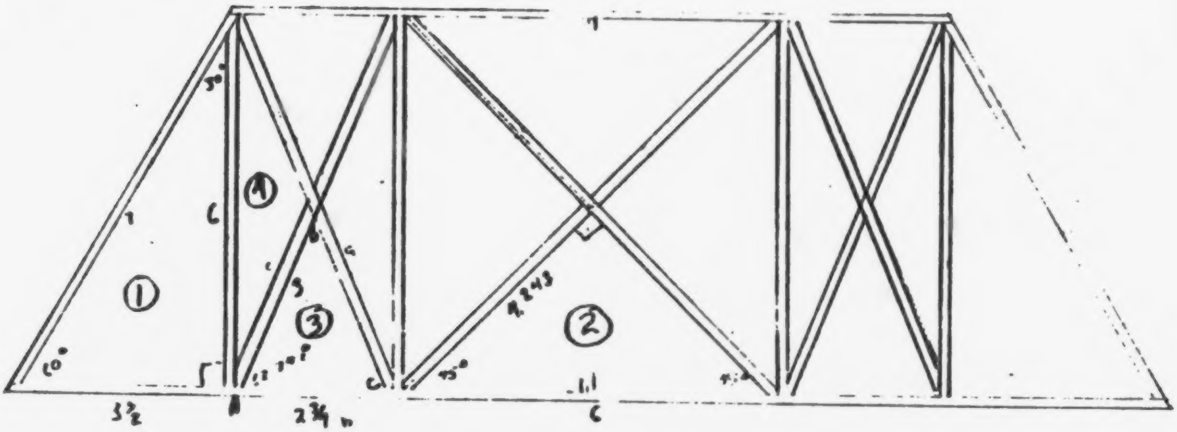
USING TRIANGLES and TRIGONOMETRY FOR PROBLEMS IN ENGINEERING

TRIGONOMETRIC FUNCTIONS OF THE TRIANGLE

INSTRUCTIONS PREPARED BY MR. WILLIAM C. BLOUGH FOR THE INTRODUCTION TO ENGINEERING PROGRAM AT BUFFALO GAP H.S.

TRIANGLES RELATED TO BRIDGE BUILDING

3/8 SCALE


7
30°
6
④
7
①
60°
3½
A
2¾ in
B
6
c
3
③
6
4.243
②
45°
C
6

TRIANGLE

1. 30°, 60°, 90° Formula $2a = c$ $2 \cdot 3.5 = c$ $7 = c$

2. 45°, 45°, 90° Formula $a = \sqrt{2} \cdot x$ $\frac{a}{\sqrt{2}} = x$ $\frac{6}{\sqrt{2}} = x$ $4.243 = x$

3. Law of Cosines $a^2 = b^2 + c^2 - 2bc \cos A$

$\frac{b^2 + c^2 - a^2}{2bc} = \cos A$ $\frac{2.75^2 + 3^2 - 3^2}{2 \cdot 2.75 \cdot 3} = \cos A$ $.458 = \cos A$

$62.742° = A$

A = 62.742°

B = 54.516°

C = 62.742°

4. ∠A = 27.258
∠B = 125.484
∠C = 27.258

TRIANGLES

The solution of triangles and vectors is important to the engineering and building professions, because a triangle, unlike any other geometric form, is the only rigid structure. Any time its angle is changed, a member length must be changed to accommodate the angle change. Conversely, any time a member length is changed, an angle must be changed. Therefore, once a triangle is fixed, it will remain fixed unless it fatigues or is physically broken down by a force or pressure.

The square, on the other hand, can be subjected to forces which will cause the square to change its intersecting angles, while the member lengths will remain the same. Angles can be changed in the same way within other geometric shapes as well, except for the triangle. For this reason, the triangle is the shape chosen for solving in trigonometry and by engineers for construction purposes.

Although solving of triangles is nothing new to the engineering profession, it is new to the Pre-engineering course in Technology Education. This area of math must be explored for its potential in updating the Technology Education curriculum.

Triangles can be divided into four categories. They are as follows:

(1) 30°- 60°- 90°

(2) 45°- 90°

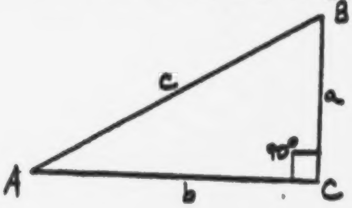
(3) odd right triangle

(4) irregular triangle

For each of the triangle groups above, there is a specific set of formulas for solving them. Solving means finding member lengths, angles, etc. Once you solve the triangle, then this will allow you to plot/solve vectors, which show the resultant force and direction of that force on the members.

In physics there are some useful facts about triangles that are used to solve problems about forces and velocities.

1. 30°- 60°- 90° right triangle.- It is useful to remember that the hypotenuse of such a triangle is twice as long as the side opposite the 30° angle.
2. 45°- 45°- 90° right triangle. The sides opposite 45° angles are equal. The length of the hypotenuse is $\ell \cdot 2$, where ℓ is the length of a side.
3. Trigonometric functions. These are ratios of the lengths of sides of a right triangle and depend on the magnitude of one of its acute angles. Using right triangle ABC, below, we define the following trigonometric functions of $\angle A$:



sine $\angle A = \frac{a}{c}$

cosine $\angle A = \frac{b}{c}$

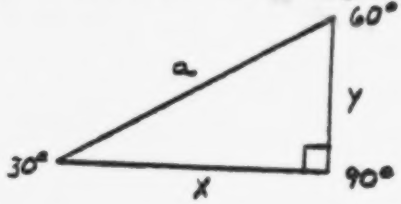
tangent $\angle A = \frac{a}{b}$

These functions are usually abbreviated as sin A, cos A, tan A.

$30^\circ - 60^\circ - 90^\circ$ TRIANGLE

For right triangles like the $30^\circ - 60^\circ - 90^\circ$ triangle, you must know two sides or one side and one angle to calculate.

Formulas:



Solving for the hypotenuse (H):

$H = 2 \cdot$ short side (y)

Solving for the long side (x):

long side $(x) = \sqrt{3} \cdot$ short side (y)

Example:

Find the short side (y):

$x = 6$

$x = \sqrt{3} \cdot y$

$6 = \sqrt{3} \cdot y$

$\frac{6}{\sqrt{3}} = y$

$3.46 = y$

Find the hypotenuse (H):

$a = ?$

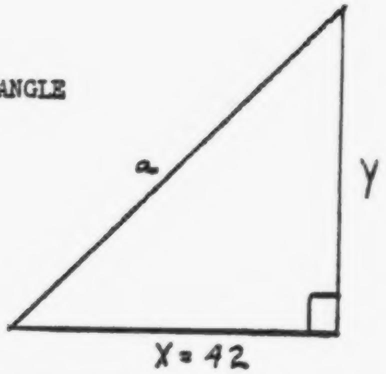
$2 \cdot y = H$

$2 \cdot 3.46 = H$

$6.92 = H$

45° TRIANGLE

Formula:



If x is horizontal and y is vertical, with a as the hypotenuse, then $x = y$.

To solve for the hypotenuse (a):

$$a = \sqrt{2} \cdot x$$

Examples:

Find the hypotenuse (a):

$x = y$

$x = 42$

$y = 42$

$$a = \sqrt{2} \cdot x$$

$$a = \sqrt{2} \cdot 42$$

$$a = 59.39$$

Find x/y when hypotenuse (a) is known:

$a = 10$

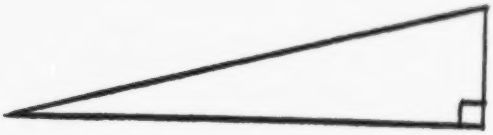
$$a = \sqrt{2} \cdot x$$

$$10 = \sqrt{2} \cdot x$$

$$\frac{10}{\sqrt{2}} = x$$

$$7.07 = x$$

ODD RIGHT TRIANGLE



The total degrees in the angles of a triangle must equal 180°. Therefore, $A + B + C = 180°$.

To find the side lengths or member lengths, use the following formulas:

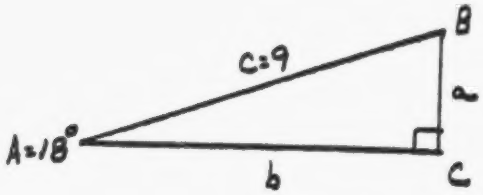
Name	Definition
sine	$\frac{\text{opposite side}}{\text{hypotenuse}}$
cosine	$\frac{\text{adjacent side}}{\text{hypotenuse}}$
tangent	$\frac{\text{opposite side}}{\text{adjacent side}}$
Pythagorean Theorem	$c^2 = a^2 + b^2$ or $c = \sqrt{a^2 + b^2}$

Examples:

$A + B + C = 180°$

$180° - (A + C) = B$

$180° - (18 + 90) = 72°$



Solve for a:

$\text{Sin} A = \frac{a}{c}$

$\text{Sin } 18° = \frac{a}{9}$

$\text{Sin } 18° \cdot 9 = a$

$2.78 = a$

Solve for b:

$\text{Cos } A = \frac{b}{c}$

$\text{Cos } 18° = \frac{b}{9}$

$\text{Cos } 18 \cdot 9 = b$

$8.56 = b$

ODD RIGHT TRIANGLES contd.

Examples contd:

To solve using the Pythagorean Theorem:

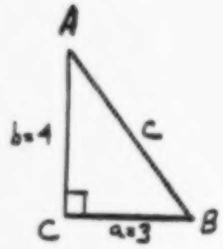
$$c^2 = a^2 + b^2$$

$$c^2 = 3^2 + 4^2$$

$$c^2 = 9 + 16$$

$$c^2 = 25$$

$$c = 5$$



Solve for c:

$$\text{Tan } B = \frac{\text{opposite side}}{\text{adjacent side}}$$

$$\text{Tan } B = \frac{b}{a}$$

$$\text{Tan } B = \frac{4}{3}$$

$$^{*}\ \text{Tan } B = 1.33$$

$$\angle B = 53.13^\circ$$

* Tan is a function to find the proportion of sides. When Tan B is remaining, use the inverse key and then the Tan key for the answer in degrees.

$$A = 180^\circ - (B + C)$$

$$A = 180^\circ - (53.13^\circ + 90)$$

$$A = 180^\circ - 143.13^\circ$$

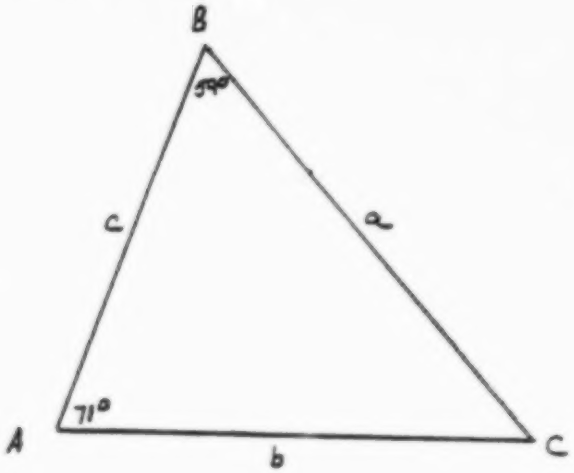
$$A = 36.87^\circ$$

IRREGULAR TRIANGLE (no 90° angle)

To solve using the Law of Sines, you must know at least three parts of the triangle, and at least one of those parts must be a side.

Law of Sines: $\frac{a}{\text{Sin } A} = \frac{b}{\text{Sin } B} = \frac{c}{\text{Sin } C}$

Example:



$A + B + C = 180°$

$180° - (A + B) = C$

$180° - (71° + 59°) = C$

$180° - 130° = C$

$50° = C$

Solve for a:

$$\frac{a}{\text{Sin } A} = \frac{c}{\text{Sin } C}$$

$$\frac{a}{\text{Sin } 71°} = \frac{10}{\text{Sin } 50°}$$

$$a = \frac{10 \cdot \text{Sin } 71°}{\text{Sin } 50°}$$

$$a = 12.34$$

Solve for b:

$$\frac{b}{\text{Sin } B} = \frac{c}{\text{Sin } C}$$

$$\frac{b}{\text{Sin } 59°} = \frac{10}{\text{Sin } 50°}$$

$$b = \frac{10 \cdot \text{Sin } 59°}{\text{Sin } 50°}$$

$$b = 11.19$$

IRREGULAR TRIANGLE contd.

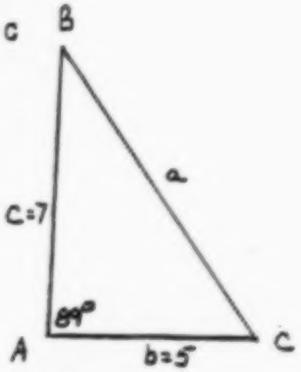
To solve the irregular triangle when all three sides are given, the Law of Cosines is used to find the angle.

Formulas:

$a^2 = b^2 + c^2 - 2bc \text{ Cos } A$

$b^2 = a^2 + c^2 - 2ac \text{ Cos } B$

$c^2 = a^2 + b^2 - 2ab \text{ Cos } C$



Example:

$\angle A = 89°$

$c = 7$

$b = 5$

Solve for a:

Step 1: $a^2 = b^2 + c^2 - 2bc \text{ Cos } A$

$a^2 = (5)^2 + (7)^2 - 2(5)(7) \text{ Cos } 89°$

$a^2 = 25 + 49 - 78 \cdot \text{Cos } 89°$

$a^2 = 72.78$

$a = 8.5$

Step 2: $\frac{a}{\text{Sin } A} = \frac{b}{\text{Sin } B}$

$\frac{8.5}{\text{Sin } 89°} = \frac{5}{\text{Sin } B}$

$\frac{8.5}{\text{Sin } 89.5} = \frac{1}{\text{Sin } B}$

$\frac{\text{Sin } 89.5}{8.5} = \text{Sin } B$

$.588 = \text{Sin } B$

$36.026° = B$

Step 3: $A + B + C = 180$

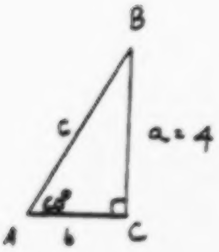
$180 - (A + B) = C$

$180 - (89° + 36.026°) = C$

$54.974° = C$

TRIANGLE PROBLEMS

1.



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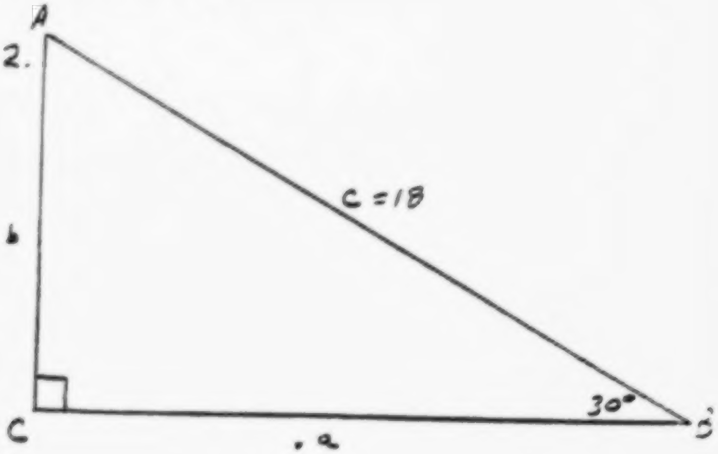
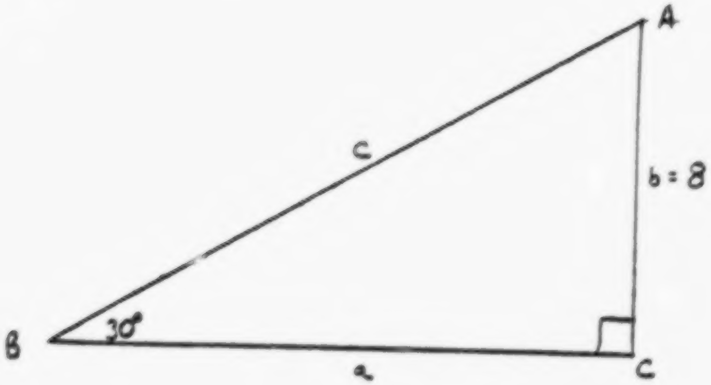

A
b
c=18
30°
C
a
B

3.



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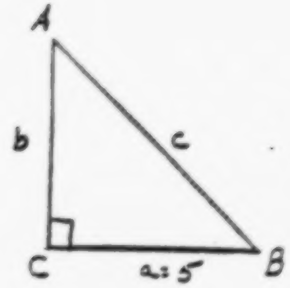

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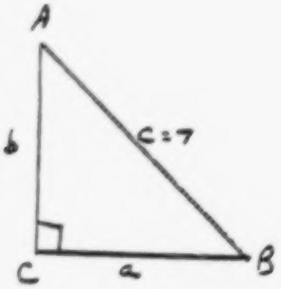

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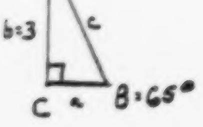

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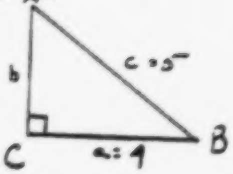

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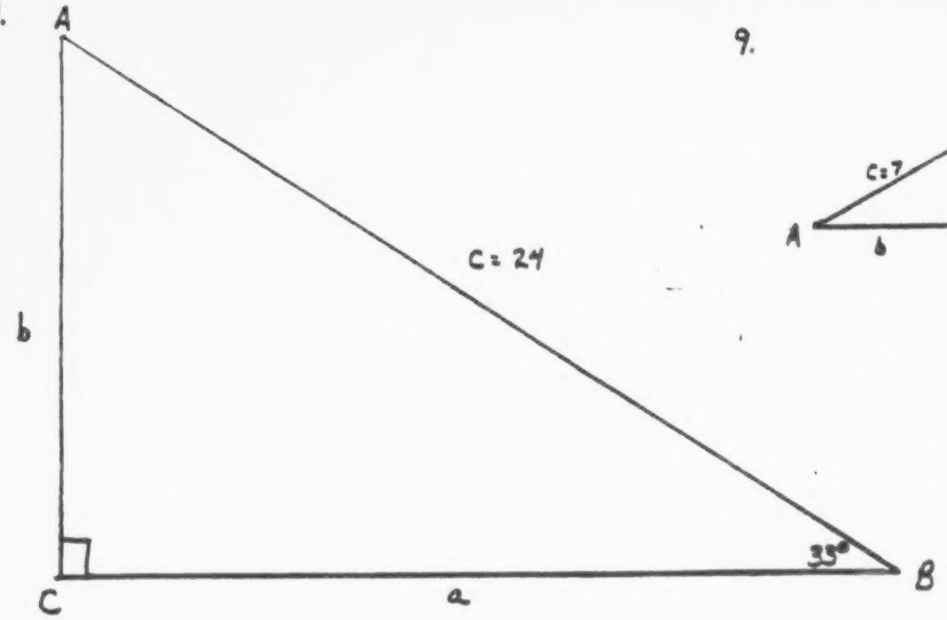
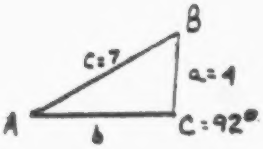
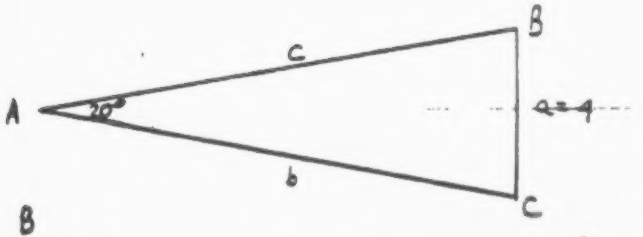

A
c = 24
b
35°
C
a
B

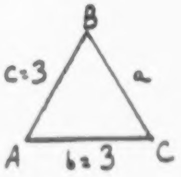
9.


B
c=7
a=4
A
b
C=92°

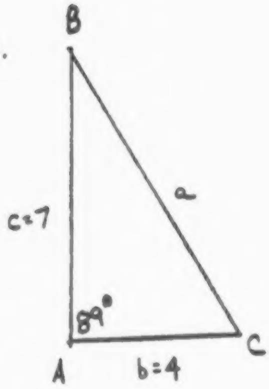
10.



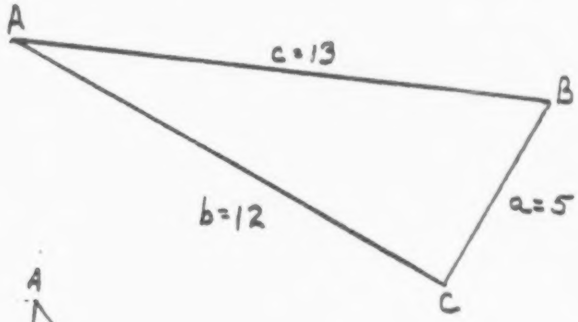
11.



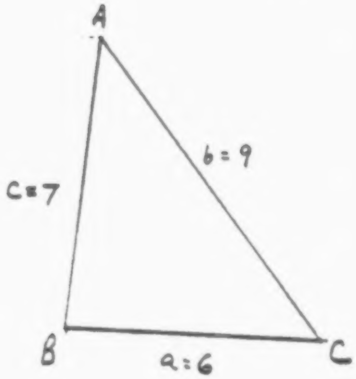
12.


B
a
c=7
89°
A
b=4
C

13.


A
c=13
B
b=12
a=5
C

14.



1. **ANALYSIS** - breaking up of any whole into parts to determine the relationship or functions of its parts - involves simplification of a real-life problem into manageable parts

2. **ARTIFICAL INTELLIGENCE** - the property of a machine capable of reason by which it can learn functions normally associated with human intelligence

3. **CASE STUDY** - a compact written description of an actual problem situation from industry that a student can project himself or herself into and perform some of the work needed - combines some of the technical detail with personal viewpoint - presents the high points of engineering experience-offers glimpses of engineering experience to the student illustrates the interfaces between theory and practice

4. **COMPUTER GRAPHICS** - involves the application of the capabilities of a computer to the analysis and synthesis of engineering problems and the communication of solutions in a graphic format

5. **DESCRIPTIVE GEOMETRY** - a set of principles which enable the geometry of an object to be identified and delineated by graphic means. It is the theory by which spatial problems involving angles, shapes, sizes, clearances, and intersections are solved

6. **DESIGN** - the process of inventing physical things that display new physical order, organization, or form in response to function

7. **DESIGN PROCESS (ENGINEERING DESIGN PROCESS)** - establishes and defines solutions to and pertinent structures for problems not solved before, or new solutions to problems which have been solved in a different way. The ability to design is both science and an art. Science of design can be learned by course study; art can be learned only by doing design - the function of creating a technical plan to solve a problem - the method by which an engineer does his work regardless of his field of specilization or the complexity of the problem - a creative and iterative approach to problem solving - the systematic process by which a solution to a problem is created

8. **ENGINEER** - a problem solver - a human link between the scientist and the consumer - one who takes knowledge into useful application providing for mankind's material needs and well being - provides designs for the purpose of easing the burdens of man's physical toil and to convert the materials and forces of nature to the use of all mankind

9. **ENGINEERING** - the profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgement to develop ways to utilize, economically and with concern for the environment and society, the materials and forces of nature for the benefit of mankind

10. **EXPERIMENTATION** - a process that leads to discovery of something not previously known. In a student lab experimentation may serve to give insight into scientific principles developed in a text.

11. **FAILURE** - a conduction caused by either rupture, excessive deformation, or loss of required geometry through wear or corrosion so that the structure, device, or component can no longer fulfill its purpose. Such failures are caused by design errors or deficiences in the design or the selection of material, imperfections in material due to manufacture, overleading or other abuses in service, inadequate maintenance and repair or environmental factors

12. **FAILURE ANALYSIS** - the definite procedure usually requiring the efforts of a team of people to determine the causes of a failure and propose corrective action thus translating failure analysis into design knowledge

13. **FLUID MECHANICS** - the science concerned with fluids, either at rest or in motion - a branch of the study of the dynamics of non-rigid bodies - fluids are classified as liquids or gases

14. **GRAPHIC ARTS** - those methods of applied arts used to form a visual end product that conveys information or is a decoration - methods include drawing, painting, photography, all types of printing, photography, all types of printing, and bookmaking

15. **GRAPHICS** - the art of drawing a three - dimensional object on a two-dimensional surface according to mathematical rules of projection - involved the

application of graphic principles and practices to the solution of engineering problems - the language of engineers

16. **HYDRAULIC** - operated or effected by the action of water or other fluid of low viscosity

17. **INSPECTION** - involvess the acceptance or rejection of a product based on a comparison of the attributes of a product wiith specifications

18. **INVENTION** - a new device, contrivance, or process devised fabricated for the first time

19. **MANAGEMENT** - supervision and control of personnel and resources required for the development and design of new technology products or processes - the making of decisions involving equipment, the labor force, and the financial assets of a company to produce a desirable product in a competitive environment or to successfully conduct a plant's operations

20. **MANAGEMENT ENGINEERING** - a main specialty area in industrial engineering concerned with the design, improvement, and installation of integrated systems of people, materials, and equipment

21. **MATERIALS** - a part of the matter in the universe - substances whose properties make them useful in structures, devices, machines or products

22. **MATERIALS SCIENCE** - the study of the nature, behavior, and use of materials applied to engineering - an interdisciplinary study of chemistry, physics, and crystallography

23. **MECHANICS** - a branch of science that deals with the behavior of physical systems under the action of forces - divided into the study of statics and dynamics

24. **MODEL** - a concept, a mental picture, a graph, a mathematical equation which helps to explain or understand observations - a human idea subject to change - something that describes a problem - an idealization of a real-world situation that aids the designer in the analysis of a problem - an aid to visualizing and thinking about a problem

25. **MODELING** - describing a problem

26. **PATENT** - a certificate of grant by a government of an exclusive right with respect to an invention for a limited period of time

27. **PROBABILITY** - in a problem of evaluating the chance or likelihood of the occurence of an event a number is associated with each event to measure the likelihood of the occurence of the event. The unique number assigned to an event is called the probability of the event. Ex.: the relative frequency of an event which has occured in ways, of which are considered successful the probaliblity of a successful event is n/m

28. **PROCESS** - the means by which materials are made or transformed into a product

29. **PRODUCT** - something made by industry - the completed objective of a project - Ex.: a new bridge

30. **PROJECT** - usually an activity that produces a product over a long time duration. Ex.: a new building

31. **QUALITY ASSURANCE** - basically a management method for managing quality control activities and ensuring a viable quality control function is in operation - the total set of operations and procedures included within the production system whoses goals are conformance of product output to design specifications

32. **QUALITY CONTROL** - concerns itself primarily with the prevention of defects and the detection of product deficiences - refers to the statistical procedures employed in sampling production and monitoring the variability of the product

33. **RESEARCH AND DEVELOPMENT (R&D)** - basic or pure research expands existing knowledge - applied research employing research engineers is directed more toward the practrical side of the problem of finding a use for the discovery of new knowledge Development involves the production of a process, system, or machines that will use the principles involved in the discovery and be commercially useful and profitable

34. **SCIENTIFIC LAW** - a general description of the behavior of matter

35. **SCIENTIFIC METHOD** - a progression of events through which new scientific knowledge enlarges the body of existing knowledge. This sequential process starts with existing knowledge and procedes through scientific curiosity, hypothesis, logical analysis, acceptance as proof and communication to the scientific community completing a knowledge loop linking all components in the process.

36. **SCIENTIFIC PRINCIPLE** - describes a more specific behavior of matter than laws

37. **STATISTICS** - a branch of scientific method used in dealing with phenomena that can be described numerically for purpose of analysis in order to base decisions on them - a body of methods for making wise decisions in the face of uncertainty

38. **STATISTICAL ANALYSIS** - using statistical tools as parameters, inferences, tests of hypotheses, confidence limits, and analysis of variance to develop known properties of a statistical distribution of data which provides a basis for engineering decision making

39. **STRUCTURE** - a building, bridge, tank, highway, or the like, that is built or constructed and designed to sustain a load

40. **SYNTHESIS** - the process of modeling - assembly of the elements of a problem into a workable whole - a pulling together

41. **SYSTEM** - an entire combination of hardware, information and people necessary to accomplish some specified mission

42. **SYSTEMS DESIGN** - the techniques developed to ensure that all components of a design system work harmoniously as a coherent unit

43. **SYSTEMS ENGINEERING** - the design of a complex interrelationship of many elements (systems) to maximize an agreed upon measure of system performance, taking into consideration all of the elements related in any way to the system

44. **TECHNOLOGY** - the application of science to achieve a practical goal or purpose

45. **TESTING** - a culminating activity in the development of products in which the structural and operational performance of a product is examined and serious flaws uncovered - the objectives of testing may be, 1.) to supply routine information on the quality of a product, 2.) develop new or better information or known materials or to develop new materials, or 3.) obtain accurate measures of fundamental properties. Exs.: hardness tests, endurance testing, human acceptance, destructive and non destructive and non destructive testing

46. **THERMODYNAMICS** - a branch of physics that deals with the transformation (or reverse) of heat into other forms of energy, and with the laws governing such conversions

APPENDIX H

LABORATORY FACILITIES AND EQUIPMENT LIST

FACILITIES AND EQUIPMENT NEEDS FOR INTRODUCTION TO ENGINEERING PROGRAM

-INTRODUCTION-

The laboratory facilities for the Introduction to Engineering program should be a general or multipurpose —— like a Materials and Processes type lab. The facilitly should be accessible to a technical drawing lab, and electronics lab or have these facilities within the general purpose area. The facility should include a scientific lab for experimentation and testing. A reference/resource area should be designated in an area within the lab, or in the drawing and planning area.

Some draft layouts are included in this section for ideas of the type of facilities that may be designed for the program. No official adoption of any of the enclosed plans have been made, however the curriculum committee is studying the ideal lab facility for the program.

The equipment required for the program will include the equipment used in the Materials and Processes lab, however additional "special" equipment will be needed. The equipment list is included in this section.

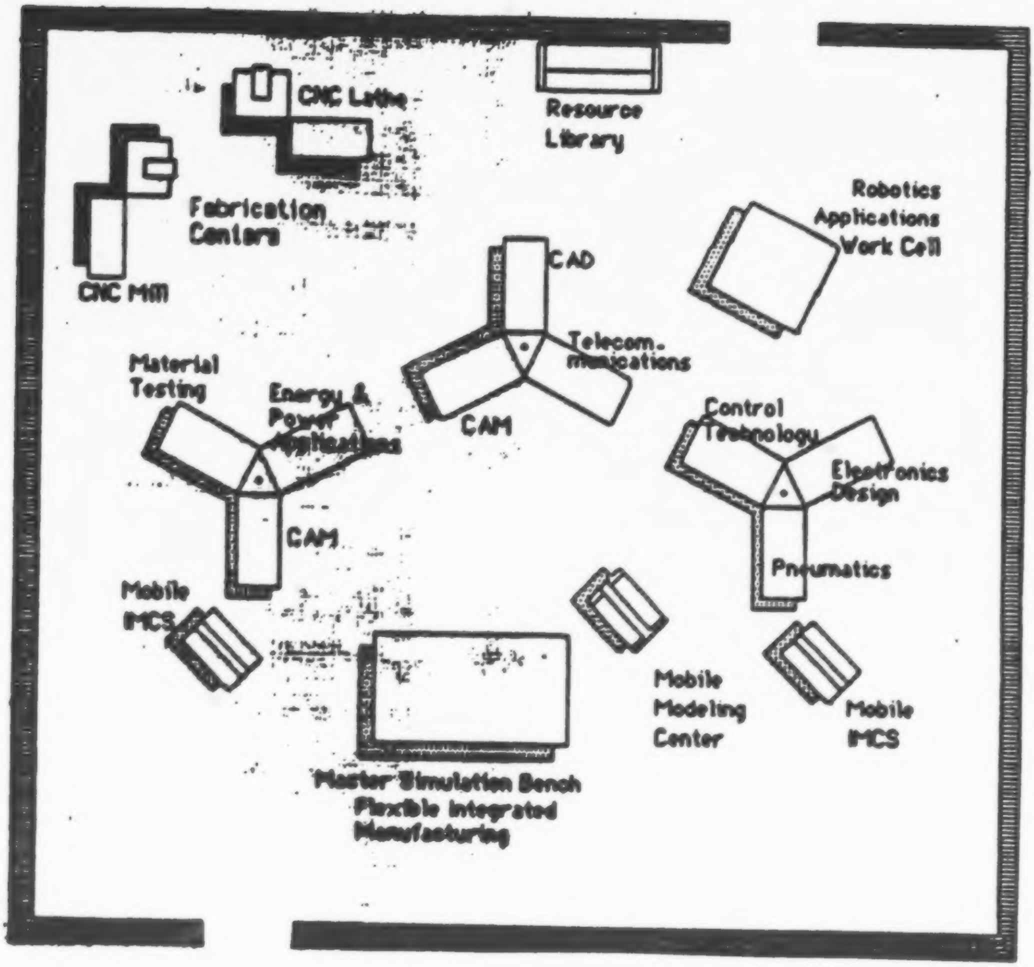
The facilities layout and equipment lists included in this section is in a draft stage, however it may be used for planning the Introduction to Engineering program.

Draft, July 1986

SPECIAL EQUIPMENT FOR THE INTRODUCTION TO ENGINEERING PROGRAM

1. Computer Aided Drawing System (CAD)
2. Basic Electricity/Electronics Equipment
3. Electronic Test Equipment
4. Calculators (Electronic/Scientific)
5. Computer (Micro)
6. Universal Tester
7. Laser (Class 2)
8. Balance Beam Scale (Digital)
9. Selected Audio Visual Equipment
10. Specialized Model Building Equipment
11. Microscope (Metalurgical)
12. Special Safety Equipment
13. Pneumatic and Hydraulic Trainer
14. Camera Equipment (35mm)
15. Electronic Timing Devices
16. Surveying Equipment
17. Plotting Equipment
18. Printers for Computers

Draft, July 1986


CNC Lathe
Resource Library
Fabrication Centers
CNC Mill
Robotics Applications Work Cell
CAD
Telecom-munications
CAM
Material Testing
Energy & Power Applications
Control Technology
Electronics Design
CAM
Pneumatics
Mobile IMCS
Mobile Modeling Center
Mobile IMCS
Master Simulation Bench Flexible Integrated Manufacturing

SUGGESTED ADDITIONS TO THE PLAN ABOVE ARE:

MODEL/PATTERN PREPARATION AREA
DRAWING, DESIGN, AND PLANNING/CAD AREA

TECHNOLOGY LAB FOR INTRODUCTION TO ENGINEERING

This drawing created on Technology LabWare (TM) software·
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APPENDIX I

INSTRUCTIONAL MATERIALS

I. Transparency Masters
  A. Problem Solving Process
  B. General Information

II. Student Handouts

III. Sample Group Project on Elevator

IV. Sample Lesson Plan

ENGINEERING APPROACH TO DESIGN

Problem Solving Steps

I. PROBLEM FORMULATION & CRITERION STATEMENTS

II. CONSTRAINTS TO THE DESIGN

III. ALTERNATE DESIGNS IDENTIFIED OR INVENTED

IV. ANALYSIS OF FACTORS THAT AFFECT PERFORMANCE

V. MONITOR RESULTS FOR OPTIMIZATION, TESTING & IMPLEMENTATION

These problem solving steps were suggested by Dr. Thomas T. Liao, Professor and Chair, Department of Technology and Society, College of Engineering and Applied Sciences at SUNY-Stony Brook.

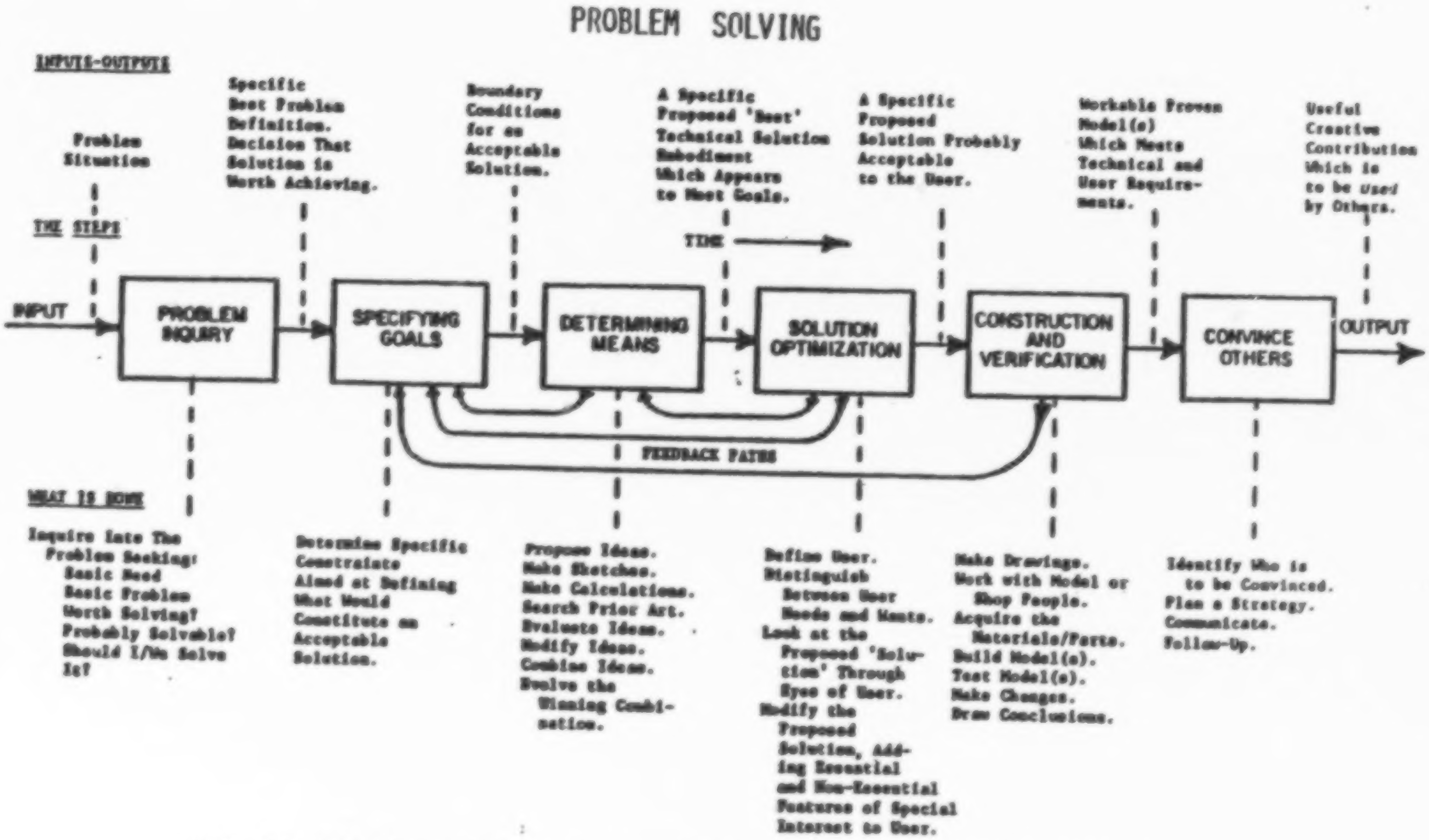
PROBLEM SOLVING
INPUTS-OUTPUTS
Problem Situation
Specific Best Problem Definition. Decision That Solution is Worth Achieving.
Boundary Conditions for an Acceptable Solution.
A Specific Proposed 'Best' Technical Solution Embodiment Which Appears to Meet Goals.
A Specific Proposed Solution Probably Acceptable to the User.
Workable Proven Model(s) Which Meets Technical and User Requirements.
Useful Creative Contribution Which is to be *Used* by Others.
TIME
THE STEPS
INPUT
PROBLEM INQUIRY
SPECIFYING GOALS
DETERMINING MEANS
SOLUTION OPTIMIZATION
CONSTRUCTION AND VERIFICATION
CONVINCE OTHERS
OUTPUT
FEEDBACK PATHS
WHAT IS DONE
Inquire Into The Problem Seeking: Basic Need Basic Problem Worth Solving? Probably Solvable? Should I/We Solve It?
Determine Specific Constraints Aimed at Defining What Would Constitute an Acceptable Solution.
Propose Ideas. Make Sketches. Make Calculations. Search Prior Art. Evaluate Ideas. Modify Ideas. Combine Ideas. Evolve the Winning Combination.
Define User. Distinguish Between User Needs and Wants. Look at the Proposed 'Solution' Through Eyes of User. Modify the Proposed Solution, Adding Essential and Non-Essential Features of Special Interest to User.
Make Drawings. Work with Model or Shop People. Acquire the Materials/Parts. Build Model(s). Test Model(s). Make Changes. Draw Conclusions.
Identify Who is to be Convinced. Plan a Strategy. Communicate. Follow-Up.

FIG. 3-1 The six-step system approach to solving in a mature disciplined manner an engineering problem requiring a creative solution. The figure gives an overview of the approach.

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P. O. BOX 1425, ANN ARBOR, MI 48106

PROBLEM SOLVING PROCESS

1. ACCEPT THE SITUATION
2. ANALYZE WHAT IS INVOLVED
3. DEFINE THE PROBLEM
4. IDEATE SOLUTIONS
5. SELECT BEST DECISION
6. IMPLEMENT DECISION
7. EVALUATE RESULTS
8. RECYCLE IF REQUIRED

ENGINEERING PROBLEM/PROJECT

State A Problem	What could you do to improve a small table fan?
Collect Information	It may be that the fan you use at home is working good. But, how good is it working? Find out how much air your fan produces. Calculate speed and volume. How does your fan compare to your other fans, or those used by your friends or relatives.
Create Ideas and Solutions	What are some ways you might try to improve your fan? Electrically? Mechanically? Could you make the motor run faster? Could you change the blades? How much electricity is used?
Make Technical Changes	Make the changes to a fan that will improve it. Ask people to help you or look for books to help. Work safely with tools and machines to improve your fan.
Report Results	1. Use a chart to show results. 2. Write a technical report of your solution. 3. Tell someone how you improved a small fan.

Students' spatial visualization skills decline

The spatial/visual skills of high school seniors, important foundations for scientific, medical, and engineering occupations, declined dramatically between 1960 and 1980, an ETS research study reports.

The study compared a national sample of randomly selected twelfth-graders at public, parochial, and private schools in 1960 and again in 1980. The same 16-item test, "Visualization in Three Dimensions," was administered to both samples.

Each item depicted a flattened geometric form and asked the student to select which of five objects could be made by folding or twisting the flattened piece. Reading speed and comprehension were also measured.

It was discovered that:

▶ High school *seniors* in 1980 performed at the same level as the high school *freshmen* who were sampled in 1960. That is true for the mean scores of males, of females, and of total samples.

▶ The raw score difference between male and female high school seniors decreased by one third between 1960 and 1980.

▶ The decline in visualization was substantially greater than the decline in reading: males declined 33 percent more in visualization than in reading, while females declined 16 percent more.

▶ There was essentially no difference between the males and the females in reading in either 1960 or 1980, but both declined during this period.

"Why the means in visualization for the total sample should decline so dramatically from 1960 to 1980 is not clear," says Thomas L. Hilton, project director. "One partial explanation might be that the higher dropout rate in 1960 created a more select group of seniors that could be expected to have higher scores in both visualization and reading."

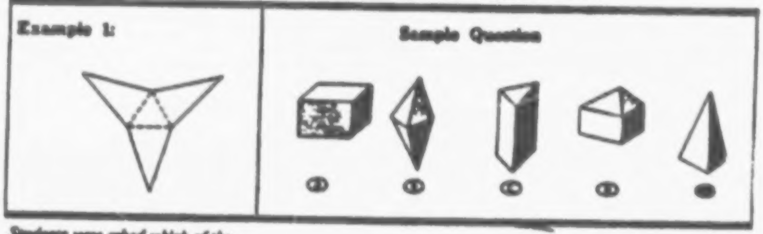
He also suggested the decline in visualization might be explained, in part, by curriculum changes away from courses like solid geometry, trigonometry, and mechanical drawing.

The findings related to differences in male and female performance proved the most puzzling. "The decline in differences in performance between the sexes seems to reflect a trend toward uniformity in experience," Hilton explained. "It is clear, however, that the substantial ability gap between males and females in 1960 still existed in 1980, and that the skills of both sexes declined appreciably during this period."

The students in 1960 were participants in Project TALENT, and the students in 1980 were participants in *High School and Beyond*, one of the national longitudinal studies sponsored by the National Center for Education Statistics.

For further information, contact: Thomas Hilton (DV), ETS, Princeton, NJ 08541-0001.

Now look at example 1 below.



Students were asked which of the objects at the right was formed by folding the flat piece at the left along the dotted lines.

Educational Testing Service
Princeton, NJ 08541-0001

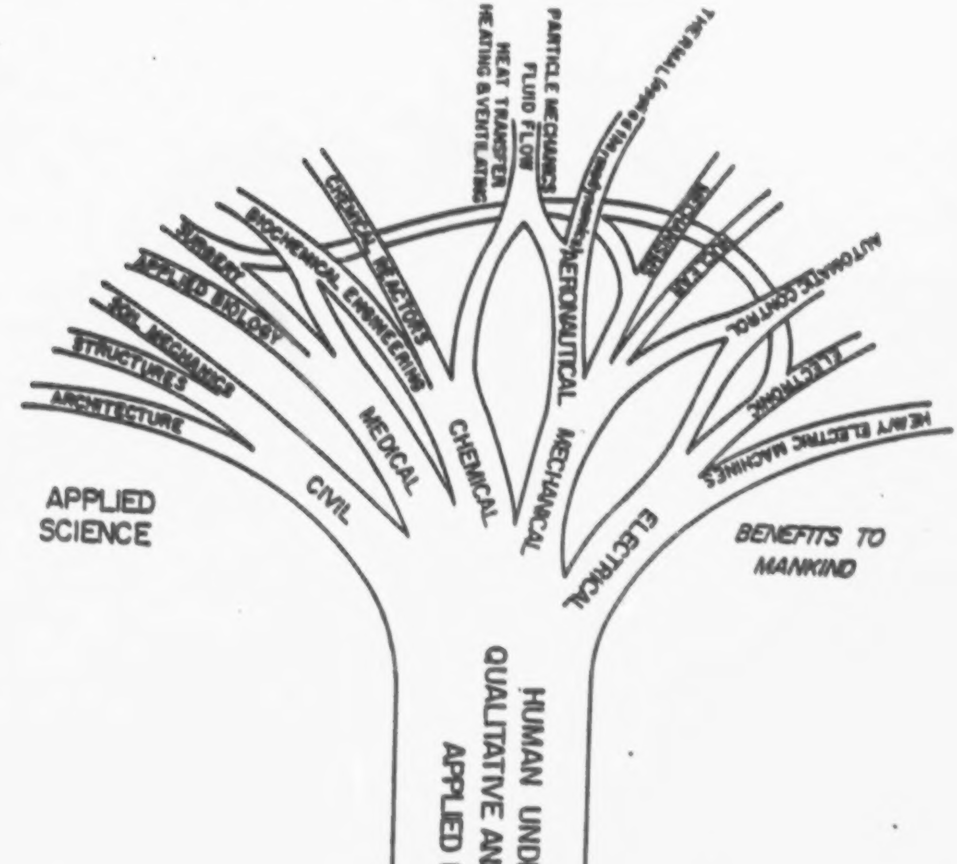

THERMAL
PARTICLE MECHANICS
FLUID FLOW
HEAT TRANSFER
HEATING & VENTILATING
CHEMICAL REACTORS
BIOCHEMICAL ENGINEERING
SURGERY
APPLIED BIOLOGY
SOIL MECHANICS
STRUCTURES
ARCHITECTURE
AERONAUTICAL
AUTOMATIC CONTROL
ELECTRONIC
HEAVY ELECTRIC MACHINES
CIVIL
MEDICAL
CHEMICAL
MECHANICAL
ELECTRICAL
APPLIED SCIENCE
BENEFITS TO MANKIND
HUMAN UNDERSTANDING
QUALITATIVE AND QUANTITATIVE
APPLIED MATHS
AESTHETICS
GEOLOGY
BIOLOGY
CHEMISTRY
PHYSICS
PURE SCIENCE
THE LAWS OF NATURE
PHYSIOLOGY
ZOOLOGY
ANATOMY
BOTANY
INORGANIC
ORGANIC
PHYSICAL
CLASSICAL
QUANTUM
NUCLEAR

FIG 1-1 Thring's tree of useful knowledge [341]

WHERE'S AMERICA GOING ???

(According to Megatrends, John Naisbitt, author)

FROM	TO
an industrialized society	an information society
a centralized society	a decentralized society
North	South
a national economy	part of an integrated global economy
forced technology	high tech/high touch
either/or	multiple option
economies of scale	appropriate scale
a managerial society	an entrepreneurial society
left brain	right brain
sickness-orientation	wellness-orientation
hierarchies	networking
representative democracy	participatory democracy
printing	telecommunications
broadcasting	narrowcasting
department-chain stores	boutiques
family as basic unit	individual as basic unit
party politics	issue politics
macho society	androgynous society
federal assistance	community enterprise
myth of the melting pot	celebration of cultural diversity
left vs. right politics	a politics of the radical center
conquerors of nature	partnership with nature
vertical society	horizontal society
top-down society	bottom-up society

INTRODUCTION TO ENGINEERING

WEEKLY LOG

UDENT ENGINEER GRADE LEVEL FIELD OF ENGINEERING

ACTIVITIES TIME

MONDAY

TUESDAY

EDNESDAY

THURSDAY

FRIDAY

THE TECHNOLOGICAL TEAM

A. CRAFTSMAN (Skilled)

1. Involves physical work
2. Rarely supervises
3. Uses less logic & math skills
4. Builders of engineering projects
5. Education: High school diploma

B. TECHNICIANS (Problem solvers)

1. Uses hands
2. Thinks logically
3. Experimental
4. Problem solving orientated
5. Education: College (2 years)

C. TECHNOLOGIST (Combination of above)

1. Works with above two & engineer
2. Most important role in field
3. Requires fundamental understanding
4. Familiar with engineering equipment
5. Education: College (4 years)

D. ENGINEER (Combination of above 3)

1. Designs structures
2. Calculates stresses & strains
3. Does little drafting
4. Important: Justification for building project
5. Education: College (5 years & Masters Degree)

E. SCIENTIST (Mental & Experimental)

1. Does no calculations
2. Studies world as it is
3. Plans for discovery
4. Work theoretically
5. Education: College (7 years minimum)

PROCEDURES FOR ELEVATOR PROJECT

1. After meeting in Hampton last year - assignment "system." Common technology thread.
2. Defina a System

   System - A component that is a total functioning unit. (Don Hedgepath)

   System - A set or arrangement of things so related or connected as to form a unit.
3. Introduced course to students - 12 students in class.
4. Students chose system to study - Elevator Low Rise Hydraulic - Holeless
   - Hole
5. I chose the group method as a means to teach the class and introduced it to the students.
6. Began Research
   a. Letters
   b. Telephone Calls - survey 23 places
7. After getting information, we started designing book display, logo and title page, and determining research topics. Page 4
   a. Gave outline for written report. Page 5
8. After design for the display was finished, it was broken down into its major parts.
   a. Base
   b. Cab
   c. Building
   d. Hoistway
   e. Hydraulics and Electrical
9. Set up personnel system and organization chart.
10. Developed basic outline for teaching course. Page 6
11. Started work on display and help progress and reporting seminars so that all in the class can learn about the different aspects of elevators. Page 7
12. Problems

    Displaying science and math principles.
13. Community Contributions

    11 Businesses - Consultant from Dover

    2 Engineering and Architectural Firms
14. School Advisory Committee

    Math Teacher - English - Science - Principal
15. Dr. Shelly with the Magnet School or Governor's School observed our work and expressed interest.
16. Nine students enrolled for next year. Good students referred to program by members of the school Advisory Committee.
17. Robotics Demonstration provided by Brodhead-Garrett Company.
18. Slides were taken throughout progress of class.
19. Elevator has been on display in public places.

CONTRIBUTORS TO ELEVATOR COMPANY

1. Mr. Ernest Reynolds
   Hydraulics-Pneumatics
   Roanoke

2. Mr. John T. Smolcnop
   Ottis Elevator Company
   Roanoke (563-0304)

3. Gibbonet Vo. Tech
   - Printing
   - Machine Shop

4. C. Arthur Weaver
   - Valve at Cost

5. Mr. Lawrence Taylor
   Dover Elevator Company
   (344-4700)

6. Dominion Elevator
   - Push Button Switches
   - Prints
   - Guide Rail

7. Imperial Elevator
   - Suggestions
   - Aluminum
   - Limit Switches

8. Gene Duggan
   Roanoke Memorial Hospital

9. Barry Mann
   Glidden Paint
   419 Roanoke, VA
   - 2 quarts: yellow, purple

10. Ben Eubank
    - Wallcoverings

11. Smithey & Boyton
    - Windows

12. Peoples Electronics
    - Eddie

Science Principles

1. Pascal's Law - Hydrostatics
2. Electricity AC/DC - a fundamental physical agency caused by the presence and motion of electrons, protons and other charged particles manifesting itself as attraction, repulsing magnetic, luminous and heating itself.
3. Kinetic Energy
4. Bernoull Law - Fluid Flow
5. Magnetism
6. Ohms Law
7. Electronics
8. Newton's Law of Motion (gravity)
9. Newton's Law of Dynamics
10. Velocity
11. Hydraulic
    a. Hydrostatics
    b. Hydrokinetics
12. Acceleration

Vocabulary & Technical Terms

Outgoing Traffic
Transfer Time
Pit
Operating Speed
Peak Traffic Periods
Loading and Operating Intervals
Capacity
Cab
Leveling
Rope
Dwell Time
Elevating
Circle Time
Critical Traffic
Critical Path
Geared Drive
Geared Traction
Gearless Traction
In-Car Count
Load
Operating Time
Platform
Queueing Space
Refuse Space
Round Trip Time
Probable Stops
Waiting Time
Interfloor Cutter
Multiplexing
Traffic

TECHNOLOGY INSTRUCTIONAL GUIDE

BY RODNEY FULTON

SYSTEMS - LOW RISE ELEVATOR

CONTENT/CONCEPT

TASKS/ COMPETENCIES	PERFORMANCE OBJECTIVE	INSTRUCTIONAL ACTIVITIES
1. List various types of elevators used in low, medium, and high rise buildings.		1. Define word "system."
2. Describe how a low rise hydraulic elevator works.		2. Introduce the method of instruction to the student: a. Group b. Unit c. Research and Experimentation
3. Explain importance of safety regulations for elevators.		3. Aid in organizing class into a personnel system.
4. Investigate the careers associated with the elevator industry.		4. Aid in organizing class into a personnel system.
5. Discuss the relationship of class to the principles of hydraulics.		5. Assist students in role playing activities.
6. Design and construct a workable display by using a variety of tools, machines, and materials.		6. Demonstrate the use of tools and machines.
		7. Act as an advisor to any of the groups or individuals.
		8. Furnish all evaluation forms, outlines for compan meetings, production reports, etc.
		9. Act as resource person and aid in directing learning activities.
		10. Evaluate student performances.

ENABLING ACTIVITIES

Select system to study.

Research all feasible aspects of industry.

Role play with their counterpart in industry.

Use tools and machines to construct modules and/or displays.

Write a report on one aspect of the system and/or an in-depth report on a specific topic.

Conduct and participate in company meetings and/or seminars.

Aid in evaluating class progress.

SCIENTIFIC PRINCIPLES APPLIED

1. Pascal's Law
2. Electricity
   a. A.C.
   b. D.C.
3. Kinetic Energy
4. Bernoulli Law
5. Magnetism
6. Ohms Law
7. Electronics
8. Newton's Laws of Motion (Gravity)
9. Velocity
10. Newton's Law of Dynamics
11. Hydraulics
    a. Hydrostatics
    b. Hydrokinetics
12. Acceleration

MATHEMATICAL PROBLEMS SOLVED

1. Area
   a. Piston
   b. Cylinder
   c. Building
   d. Car
2. Force
3. Acceleration
4. Volume
5. Velocity
6. Dwell Time
7. Travel Time
8. Horsepower
9. Speed
10. Calculations

SAMPLE TECHNOLOGY EDUCATION LESSON PLAN

(Front)

by

John A. Engineer

Lesson Title

④ Course

① Instructional Unit

TASK/COMPETENCY: (knowledge, skills, or attitudes student gains from instruction)
②

PERFORMANCE OBJECTIVE: (expected conditions, performance, and criterion or standard)
⑤

TOOLS/MATERIALS:
⑨

AUDIOVISUALS:
⑩

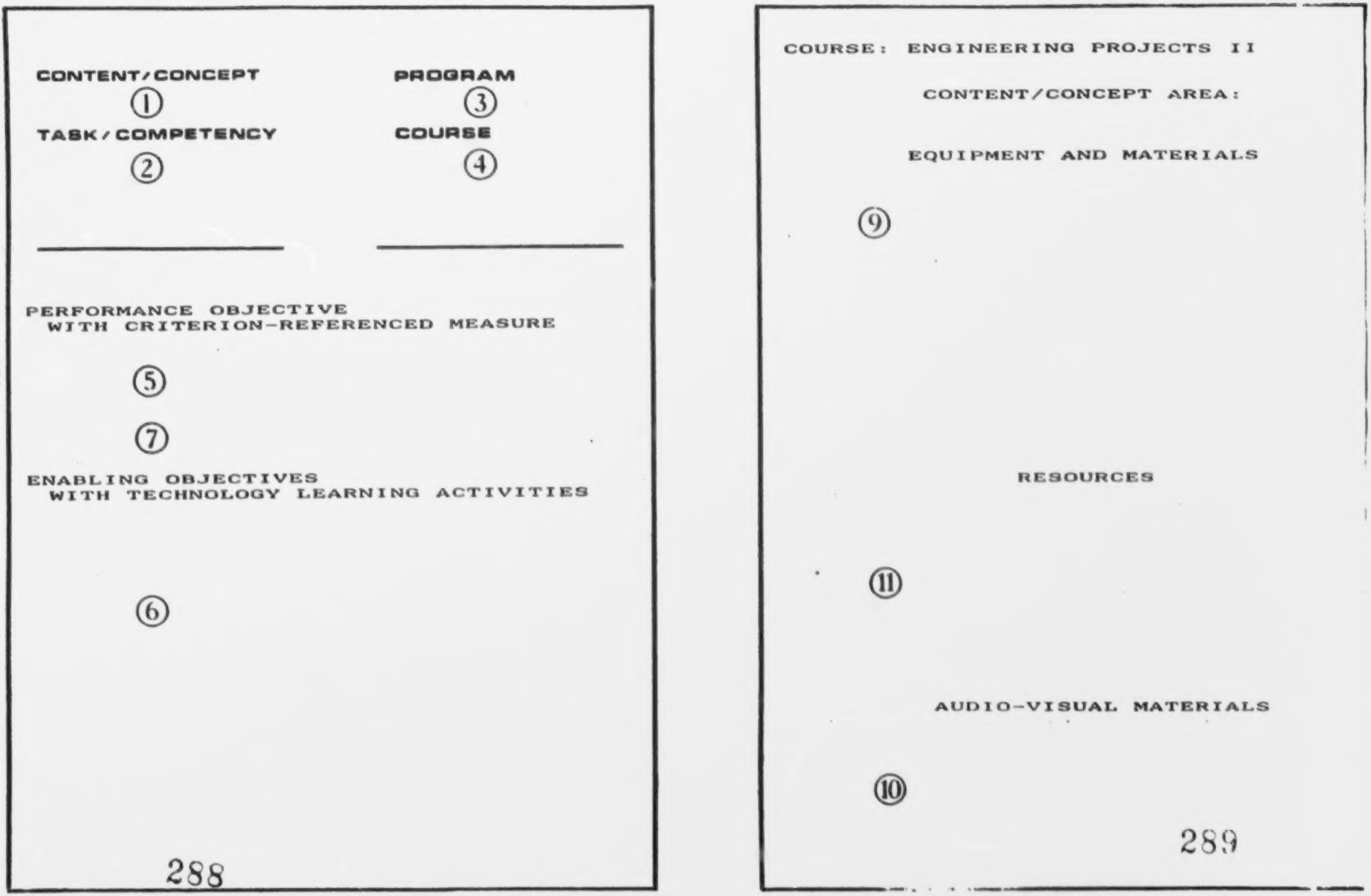
REFERENCES:
⑪

STUDENT ASSIGNMENT(S):
⑥
⑧

(Reverse Side)

PRESENTATION: (Introduction, presentation, discussion, application & evaluation) ⑤ ⑥
CRITERION REFERENCED MEASURES: ⑦
SPECIAL NOTES: (Resource persons, if any; results and follow-up)

Figure 1—Sample Task/Competency Framework Pages



CONTENT/CONCEPT
①

TASK/COMPETENCY
②

PROGRAM
③

COURSE
④

PERFORMANCE OBJECTIVE
WITH CRITERION-REFERENCED MEASURE

⑤

⑦

ENABLING OBJECTIVES
WITH TECHNOLOGY LEARNING ACTIVITIES

⑥

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COURSE: ENGINEERING PROJECTS II

CONTENT/CONCEPT AREA:

EQUIPMENT AND MATERIALS

⑨

RESOURCES

⑪

AUDIO-VISUAL MATERIALS

⑩

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APPENDIX J

JETS AND TECHNOLOGY STUDENT ASSOCIATIONS

I. JETS Information for assistance from engineers

II. Technology Student Association Activities that Teach Technology

III. Competitive Events and Rules:

Architectural Design Contest (used only in Virginia)

Bridge Building Contest (group competition at conference)

Computer Aided Design Contest

Engineering Problems Contest

Problem Solving Team Contest (group entry, used only in Virginia)

Research Paper Contest

Technology Process Display (group project)

Write for more information to:

Technology Student Assoc. Specialist
Technology Education Service
Box 6 Q
Richmond, VA 23216

804-225-2089

AIASA National Office
1908 Association Drive
Reston, VA 22091

703-860-9000

Does Your Local High School or Junior High Have a JETS Club?

Photo Exxon

JETS Clubs are designed for students interested in engineering, technology and science. An active JETS chapter—

- participates in engineering design contests;
- goes on field trips to local engineering firms, science labs and other places of interest;
- can sponsor the National Engineering Aptitude Search test;
- can compete in TEAMS, an interschool academic competition;
- will receive *JETS Report*, a newsletter promoting interest in engineering, technology and science with information on careers, scholarships and summer programs, including the Minority Introduction to Engineering Program.

JETS needs engineers who are concerned about young people's future to serve as club advisors.

JETS also wants to reach teachers and students to encourage participation.

If you are interested in starting a JETS program in your community, write for a free "Starter Kit." Or call (212) 705-7690.

Engineering Careers Get a Good Start with JETS!

JETS

(703) 548-5387

JETS, Inc., 345 East 47th St., New York, NY 10017
A national, non-profit educational organization

also known as the Junior Engineering Technical Society

HOW DO I START A JETS CHAPTER ?

We mentioned the Starter Kit before. It's a big help in getting established. You can also form a club by following these few basic steps:

1. Contact a teacher or professional person who is willing to serve as a chapter advisor.
2. Announce a meeting for all students interested in engineering and science. Use the school bulletin boards, announcements in science and math classes, the school paper. Explain the goals and purposes of JETS.
3. Return the completed Application for Chapter Affiliation (below) to national headquarters together with a roster of student members. Dues are $2.00 a year for each member.
4. In those states that have state dues, the $2.00 per student national dues will be added to the state dues and remittance may be made directly to the state office.
5. Your chapter may establish its own dues structure. Your state office will provide you with a copy of its dues structure.

APPLICATION FOR CHAPTER AFFILIATION

Complete this application to register your group as an affiliated chapter of JETS. Attach membership roster and return to: *
JETS, United Engineering Center, 345 E. 47th St., New York, N.Y. 10017
together with fees. ($2.00 per member).

PLEASE PRINT Date____________

1. Name of chapter________________________

Chapter address: Street________________________

City ____________State ____________Zip ____________

2. Faculty advisor ____________Position ____________

3. Engineering advisor (if known) ____________Affiliation (society/company) ____________

4. We are: ☐ New Chapter ☐ Reaffiliating Chapter No. Dated ____________

5. Number of Members________________________

* All applications for Texas chapters should be returned with fees to Texas-JETS State Coordinating Office, Texas A&M University, College Station, TX 77843.

Advisor's signature ________________________

GUIDELINES FOR ENGINEERS TO ASSIST IN ESTABLISHING NEW JETS CHAPTERS

These guidelines are for engineers establishing JETS chapters in high schools and junior highs.

To begin with, learn as much about JETS as you can. The materials we suggest you familiarize yourself with are the JETS Starter Kit and the Chapter Handbook. They are available from national headquarters, as are back issues of the newsletter, JETS Report. The newsletter is mailed monthly during the school year to all JETS members and supporters.

One of JETS' objectives is to encourage high school students to take advanced courses in mathematics and science and to improve their communication skills. With a solid academic background in high school, students will have the option of pursuing technical careers. Meeting with engineers through JETS gives students an opportunity to learn how math and science are used by engineers to solve problems.

The way in which you approach a school is very critical. It is a good idea to visit with the principal to let him/her know you would like to encourage students to take advanced level courses in math and science and explore technical careers. Because there is resistance to establishing new clubs, point out that JETS chapters can be established by affiliating an existing science or mathematics club with the JETS organization. There is no affiliation charge and membership is only $3.00 a year per student. Find out from the principal who the math or science supervisor is, and who to approach to find a faculty member to sponsor the JETS chapter. The critical element in any JETS organization is a faculty member who will devote the time to work with students. If you meet resistance in finding a faculty member, you may want to visit with some of the students leaders to get suggestions from them on establishing a club. They may wish to contact a teacher to help them form a chapter.

When a potential JETS chapter faculty advisor is identified, visit with the faculty member and offer support. If you are a member of a professional engineering society, your local chapter may wish to be involved. Support can be offered in the following ways:

A. Help obtain an engineering advisor for the club or become one yourself.

B. Assist in establishing a "Search Center" for the National Engineering Aptitude Search. The NEAS test is offered six times a year and costs $7.00. Search centers are established in the fall.

C. Offer to assist in setting up field trips for the students to learn about engineering and science.

D. Offer to provide speakers for chapter meetings, either from the local engineering societies, or from other speakers bureaus of companies and universities.

E. Promote and conduct trips to nearby universities or community colleges for career day expositions.

F. Determine what contests are available in your state or locality for JETS students. The opportunity for academic and engineering design contests will grow as more schools become involved. The JETS' TEAMS Academic Competition is interscholastic and structured for participation at the local, state, and national levels.

Contact your JETS state coordinator for information about activities in your state. Some states have active JETS organizations and assist local chapters. Also feel free to contact the national office for any assistance you may need.

JETS, Inc.
345 East 47th Street
New York, N.Y. 10017

Phone (212) 705-7690

If you want to start your own JETS Chapter please contact:

Pamela Kurstedt
College of Engineering
VPI & SU
336 Norris Hall
Blacksburg, Va 24060
(703) 961-6642

ACTIVITIES THAT TEACH TECHNOLOGY EDUCATION

Criteria For Technology Education (4)	Technology Student Organization Activities
1. Instructional content drawn from one or more major systems	1. These technology-based Contests motivate the study of content in these systems.
a. **COMMUNICATION** Efficiently using resources to transter information to extend human potential.	Computer-Aided Design/Drafting Drawing Interpretation Electricity/Electronics Engineering Problems Graphic Logo Technical Report Writing
b. **CONSTRUCTION** Efficiently using resources to build structures or constructed works on a site.	Architectural Design* Bridge Building Construction* Dream House Exploring Technology* Safety Poster
c. **MANUFACTURING** Efficiently using resources to extract and convert raw/recycled materials into industrial and consumer goods.	Manufacturing Prototype Materials Processes Metric 500 Problem Solving Team* Technology Process Display
d. **TRANSPORTATION** Efficiently using resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and societal units through the movement of materials/goods and people.	Energy Conservation Exploring Technology* Metric 500* Problem Solving Team* Radio Controlled Car* Technology Bowl
2. A technological study organized by a. Systems b. Concepts c. Processes	2. The technology student organization is used in each class to involve all students in a management system to plan, follow procedures, apply concepts, and process materials.

*NOTE: These contests are not currently offered at the National Conference.

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[4] Ibid.

[5] Competitive Event Guidelines, AIASA National Office, Reston, VA 1985.

Criteria For Technology Education (4)	Technology Student Organization Activities
3. Instructional objectives that stress	3. These school and community activities are planned by and for students.
a. Students will know and appreciate the application of technological concepts, processes, and systems.	a. Invite speakers and arrange tours to learn from technological resource persons.
b. Students will apply tools, materials, processes, and technical concepts safely and efficiently.	b. Select service projects which make school or community improvements and apply tools, materials, process, and technical concepts of course in safe, efficient manner.
c. Students will apply skills, creative abilities, positive self-concepts, and individual potentials in technology.	c. Involve students in group leadership roles and the individual Achievement Program[6] wherein they apply skills, become more creative and develop positive self-concepts and life-long adaptability.
d. Students will solve problems and make decisions involving human and material resources, processes, and technological systems.	d. Design and manage economic activities which develop problem solving and decision-making ability with human and material resources, processes, and technological systems.
4. Concept-based laboratory experiences	4. Emphasize the technological concepts that can be learned or reinforced with activities that start in the laboratory and beyond the class and school into the real world.
5. Students learning about technology's a. Development b. Impact on people c. Impact on environment d. Impact on culture	5. Challenge students to enter contests wherein they research fundamental knowledge, write technical reports and prepare public speeches about the development of technology and its impact on people, the environment, and culture.
6. Students prepared with a. An understanding of how things work b. Functional technical skills	6. Recognize the achievements of students who have learned both to understand how things work and to use functional technical skills to carry out work and adapt to life-long learning and technological change.

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[6] AIASA Achievement Program, AIASA National Office, Reston, VA 1983.

ARCHITECTURAL DESIGN CONTEST

OVERVIEW: Students enter drawings and architectural models to enable judges to evaluate the detail, accuracy, and originality of the work and interview students for understanding and awareness of architectural practices and career opportunities. All entries will receive ribbons. Entries will be judged and the top eight (8) finalists will be interviewed by Judges. Trophies will be presented to the top three (3) finalists.

I. CONTEST PURPOSE

The purpose of the Architectural Design Contest provides recognition to students for creative design, problem solving, craftsmanship, and appropriate use of technology in preparing architectural drawings and renderings and/or models.

II. ELIGIBILITY FOR ENTRY

Student: No more than one (1) entry per contestant.
Course: Enrollees in 8437.
Teacher: No more than five (5) entries per teacher of 8437.

III. LEVELS OF COMPETITION

Level II - Grades 9 - 12

IV. TIME LIMITATIONS

A. Architectural drawings, renderings and/or models will be displayed according to times printed in Registration Packet.

B. Interviews with students will be limited to ten (10) minutes.

V. SPECIFIC REGULATIONS

A. Architectural drawings must include:

1. Foundation plan.
2. Floor plan.
3. Elevations (minimum of two).
4. Detail of some aspect of the construction, i.e., wall section, stairway, fireplace, cabinet work, etc.
5. Window and door schedule.

B. Architectural drawings must be accompanied by a rendering and/or model of the design problem.

C. Only original drawings may be entered.

D. In the event a model is submitted, its base should not exceed four (4) feet x four (4) feet. (Smaller sizes are acceptable.)

VI. PROCEDURE

A. Registration

1. Pre-conference registration must be mailed to reserve space for drawings, rendering, and/or model.
2. On-site verification must be completed at the Conference Information Desk.
3. Obtain time to set up entry from Reservation Envelope.

B. Competition

1. Set up architectural drawings, rendering, and/or model in judging room.
2. Judges rate each entry.
3. Judges total points on rating sheets to determine which ribbon to attach to each entry.
4. Accounting Committee will identify top eight (8) finalists and post appointment time for interview with Judges.
5. Contestants answer Judges' questions during interview.
6. Judges rate interview and pass Rating Sheets to Contest Coordinator.
7. Contest Coordinator tallies all ratings and passes all forms to the Accounting Committee.
8. Accounting Committee identifies 1st, 2nd, and 3rd place winners.

C. Termination

1. After judging, entries remain in the room for public viewing.
2. Top three (3) entries may be removed by Contest Coordinator for additional publicity and recognition.
3. Winners will be announced at the Awards Program.

VII. REQUIRED CONTEST PERSONNEL

VIII. CRITERIA FOR JUDGING

A. Drawings

1. Solution and Originality	15 points
2. Line Quality	10 points
3. Accuracy of Details	10 points
4. Dimensioning Accuracy	10 points
5. Lettering Uniformity	10 points
6. Neatness and General Appearance	10 points
B. Rendering and/or Model	15 points
Sub-total	80 points
C. Oral Interview	20 points
Total Points	100 points

ARCHITECTURAL DESIGN

Judge's Official Rating Sheet

Level 1 or 2 (Circle)

Entrant's I.D. -----> **Judging Criteria**												
Solution and Originality. .15 pts. max. in Drawing												
Line Quality of . . . . . .10 pts. max. Drawing												
Accuracy of Details . . . .10 pts. max. in Drawing												
Dimensioning Accuracy . . .10 pts. max. on Drawing												
Lettering Uniformity . . .10 pts. max. on Drawing												
Neatness and General . . .10 pts. max. Appearance of Drawing												
Rendering and/or Model. . .15 pts. max.												
Sub Total . . . . . . .80 pts. max.												
Oral Interview. . . . . .20 pts. max.												
Total . . . . 100 pts. max.												

I certify these results to be true and accurate to the best of my knowledge and ability.

____

Judge's Signature

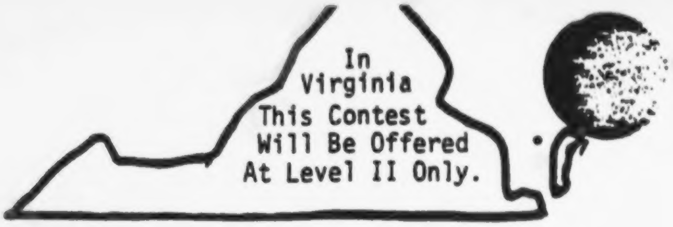
CONTEST COORDINATOR INSTRUCTION SHEET

A-1 ARCHITECTURAL DESIGN - LEVEL II

I. **Contents**
- A. Judges' Rating Sheets
- B. Contest Guidelines for the Coordinator and the Judges.
- C. List of Competitive Events Personnel.
- D. Ribbons or name badges for judges to wear.
- E. Entry list of teams in Contest A-1.
- F. I.D. tags or stick-on tabs to number models and drawings.
- G. Results envelope.

II. **Procedures**
- A. Check the contents of the Coordinator's envelope.
- B. Review the contest limitations, regulations, and procedures. Any deviation from the above by any contestant shall result in loss of points.
- C. Distribute the judges' materials and ribbons or name badges.
- D. Review the contest limitations, regulations, and procedures with the judges to clear up any questions or misunderstandings.
- E. Check in the contestants at the time printed in the program. Anyone reporting, but not on the Entry List, shall be sent to the Competitive Events Coordinator and shall only be entered upon returning with a note of approval from the Competitive Events Coordinator. Review rules with contestants.
- F. The judges will secure the architectural models and drawings in the area designated by the Competitive Events Coordinator.
- G. The judges will evaluate each entry which has been submitted using rating forms.
- H. The judges will turn in rating forms.
- I. The Accounting Committee will post a schedule when the top eight (8) students will appear for finalists' evaluation.
- J. The judges will rate each interview using rating forms.
- K. Using the results envelope provided, submit to the Accounting Committee:
  1. Competitive Events Personnel and Contestant Entry List.
  2. Judges' Rating Sheet(s).
- L. Accounting Committee identifies 1st, 2nd, and 3rd place winners.
- M. The models and drawings will be open to viewing by spectators.

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF
THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.



In
Virginia
This Contest
Will Be Offered
At Level II Only.

BRIDGE BUILDING

OFFICIAL for 1987 AIASA Contests
revision 10/86

OVERVIEW: AIASA teams (two members per team) entering the Bridge Building Contest will construct a model truss bridge to be destructively tested to determine the design efficiency of the bridge.

I. CONTEST PURPOSE

The purpose of the Bridge Building contest is to provide a means for AIASA team members to demonstrate their ability to fabricate a truss bridge after having been assigned span and width specifications.

II. ELIGIBILITY FOR ENTRY

Each chapter may enter only one team. A team will consist of two chapter members.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules

IV. TIME LIMITATIONS

The alloted time for design and construction of the bridge will be two (2) hours and thirty (30) minutes. All contestants in this event must arrive and be "in place" at the specified time and location.

V. SPECIFIC REGULATIONS

A. There shall be two (2) members per team—no more, no less.

B. All work must be done in the specified area.

C. No materials will be issued until a sketch has been provided to the judges. In the event that a tie occurs in the contest, the sketch will be used to determine the winner.

D. All tools and materials will be provided. Contestants may use as much material as their design requires. Full length wood strips will be distributed and their total length charged to each team. Unused full length strips and one partial strip may be returned to be discounted from the team's total utilized material to become the official length used in the team's efficiency formula.

E. Pins and/or fasteners used in construction of the bridge must be removed by the team when the two and one-half hours of the contest have ended.

F. The following definitions and graphic explanations are an integral part of the contest regulations.

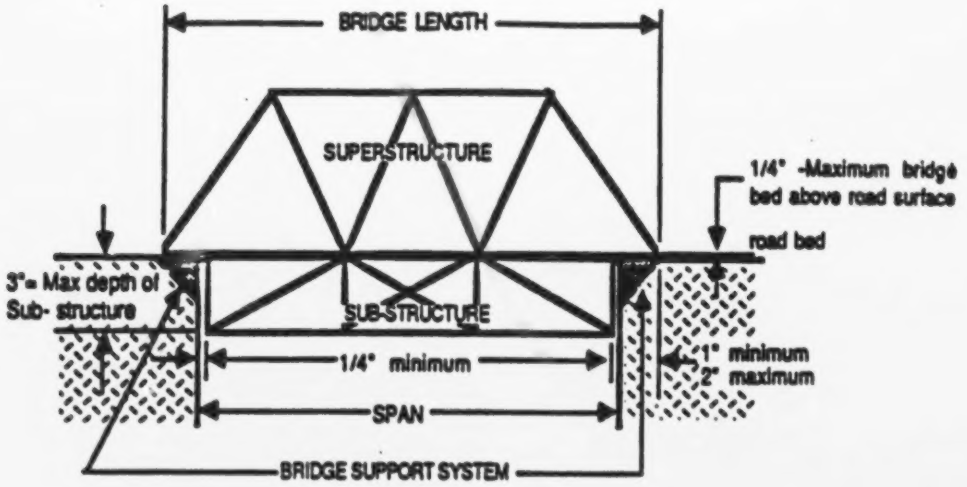

BRIDGE LENGTH
SUPERSTRUCTURE
1/4" -Maximum bridge bed above road surface
road bed
3"= Max depth of Sub- structure
SUB-STRUCTURE
1/4" minimum
1" minimum
2" maximum
SPAN
BRIDGE SUPPORT SYSTEM

DIAGRAM A-A

Bridge Length: The overall length of the bridge including the span and the required bearing surface area of the road bed (1" minimum, 2" maximum) on the bridge supports.

Truss Bridge: A bridge with a super-structure and/or a sub-structure supporting a road bed across a span.

Super-Structure: The structure of a bridge which extends above the road bed.

Sub-Structure: The structure of a bridge which extends below the roadbed. Three inch (3") maximum.

Test Block: That piece of test apparatus to which the hook that holds the weight is attached. The length of which will be 2" less than the span announced at the national conference contest. See diagram C-C.

Span: The distance between the bridge supports.

Width: The width of the bridge, measured from the outside of the beams.

Bridge Support System: The vertical edges beneath a bridge that the bridge rests upon; as river banks support a bridge across a river. The bridge supports shall be at least 6" x 6" x 6" .

Roadbed: The part of the bridge that is meant to be traveled on. The bridge must be constructed to allow the test block (without the hook) to pass through the bridge opening on the road bed from one end to the other. The roadbed must rest upon the bridge support system. The roadbed must be flat and not greater than 1/4" thick.

Failure: The point at which a truss bridge collapses or is determined to have failed due to the stresses of the load placed on it.

Lamination: Two pieces of 1/8" x 1/8" beams glued together surface-to-surface.

F. The exact span and width of the bridge to be built will be posted at the beginning of the competition. The posted specifications will be within the following limits:

Span	8" minimum
	18" maximum
Width	2.5" minimum
	5" maximum outside dimension

G. Bridges must be constructed in such a manner as to accomodate the test hook (see Diagram C-C) at the bridge's center. The road bed of the bridge must be free of obstructions.

H. Bridges will be allowed to dry a minimum of twelve (12) hours. Bridges will then be tested by applying weight until they fail.

I. A truss member may include laminations. (Refer to the definition of lamination on page 2, and to the illustration below.) Laminations may not be longer than one inch (1"). More than one lamination of 5/8" to 1" may be included on a truss or beam if a distance of 6" exists between the laminations. More than one lamination of 1/2" or less may occur on a truss or beam if a distance of one (1) inch is maintained between the laminations. One/fourth inch shall be the maximum thickness of material at a lamination. Refer to the illustration below.

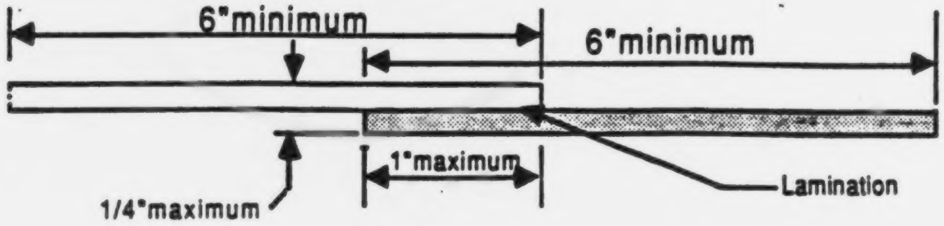


Diagram B-B

VI. REQUIRED CONTEST PERSONNEL

A. Contest Coordinator

B. Judges - A minimum of three (3) per level

C. Timekeeper/Monitor

VII. REQUIRED MATERIALS AND SUPPLIES

1. Table and chairs for judges.
2. Tables and chairs for teams. Tables should be suitable for cutting and glueing. allow table space of eight (8) square feet per team (2" x 4").
3. Stopwatch or clock for timekeeper.
4. Room - must be securable for equipment and entries.
5. Construction materials
    a. Adhesive
    b. Balsa - 1/8" x 1/8" x specific length
6. Construction tools
    a. Grid paper, 1/4" squares, 8-1/2" x 11" or 11" x 17"
    b. Fiber board, 1/2" x 12" x 12"
    c. Cutting board, 12" x 12"
    d. Single edge razor blade
    e. Straight pins
    f. Ruler, 12"

7. Testing equipment
    a. Testing block set (6,7,8,9,10,11,12,13,14,15,16)
    b. Testing hook
    c. Two five (5) gallon pails per testing station
    d. Lead shot weight
    e. Scales
    f. Calculator

8. Evaluation sheet

VIII. CRITERIA FOR JUDGING

A. Bridge efficiency shall be determined by the following formula:

$$\text{EFFICIENCY (E)} = \frac{\text{Failure Weight (in pounds or ounces)}}{\text{Length of Wood Used (in inches)}}$$

B. An increasing load will be applied to the bridge via the test hook until the bridge fails. The load will be weighed and entered in the formula as "Failure Weight."

C. Full length wood strips will be distributed and their total length charged to each team. Unused full length strips and one partial strip may be returned to be deducted from the team's total utilized material to become the official amount of material (rounded to the nearest inch) used by the team. The official amount of material used by the team will be entered in the formula as "Length of Wood Used."

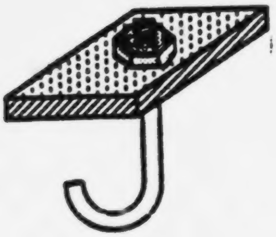


Diagram C-C
Test Block with Hook

CONTEST COORDINATOR INSTRUCTION SHEET

BRIDGE BUILDING

I. CONTENTS

A. Judges' rating sheets
B. Contest guidelines for the Coordinator and the judges
C. Competitive Events Personnel and Contest Entry List
D. Results envelope

II. PROCEDURES

A. Check the contents of the Coordinator's envelope.

B. Review the contest limitations, regulations, and procedures. Any deviation from the above by any contestant shall result in disqualification.

C. Distribute the judges' materials.

D. Review the contest limitations, regulations, and procedures with the judges to clear up any questions or misunderstandings.

E. Check in the contestants at the time printed in the program. Anyone reporting but not on the Entry List shall be sent to the Competitive Events Coordinator and shall only be entered upon returning with a note of approval from the Competitive Events Coordinator. Review rules with contestants.

F. The judges will monitor the contestants during the bridge construction.

G. At the end of the construction time, judges will collect the bridges and label each with the contestant's entry number.

H. The judges will secure the entries in an area designated by the Competitive Events Coordinator. They will also assist in taking them to the testing room the next day.

I. Using the results envelope provided, submit to the Competitive Events Coordinator:

1. Competitive Events Personnel and Contestant Entry List.
2. Judges' Rating Sheet(s).

SPECIAL NOTE: Only the testing portion of this contest is a spectator event.

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.

AIASA BRIDGE BUILDING CONTEST

JUDGE'S OFFICIAL RATING SHEET

(circle one)
LEVEL I
LEVEL II

ENTRANTS I D → **JUDGING CRITERIA**								
Check here when Bridge Plan is received. NOTE: This has no point value, however, a plan must be submitted or the entry will not be considered for competition. In case of a tie, the bridge plan is used to determine the winner.								
Check here for proper Bridge Size. NOTE: Bridge must be within the specified size limits set for this particular conference. Any bridge not of the proper size will not be considered for competition.								
Total amount of materials used. This figure is to be the linear inches of wood used to construct the bridge as described in VIII C of the contest rules. The amount of wood used shall be rounded to the nearest inch. Example: 33" NOT 32.75".								
Failure weight. The actual weight of the bucket and loading material at the time the bridge fails. Accuracy of this measure will be determined by the scale used at the conference.								
EFFICIENCY RATING See rules for proper formula. All ratings should be accurate to three decimal places. Example: 1.234								
Judges: DO NOT Mark in this area please.								

I certify these results to be true and accurate to the best of my knowledge and ability.

6 ______________________________

AIASA CAD COMPETITION
1987

OVERVIEW

THE PURPOSE OF THE COMPETITION IS TO PROVIDE STUDENTS WITH AN OPPORTUNITY TO COMPETE IN AN AREA WHERE EMERGING TECHNOLOGY PROVIDES SIGNIFICANT EMPLOYMENT OPPORTUNITY.

The AIASA CAD Competition in 1987 will have two levels of competition. The first is at the state, the second is at the national. Within the guidelines established in this document, the state level will be scheduled and conducted at the convenience of the state CAD or drafting committees. The first place winner in each state will be sent to a judging committee established by Autodesk, Inc. which will select 15 finalists in each of four categories. Each finalist will be notified and his/her school will be provided with a practice copy of the latest AutoCAD software for a minimum of one month prior to the national competition. At the national competition, these 15 students will participate in a timed competition using the same hardware and software. A judging committee at the competition will select the top three winners based on criteria established and explained to the students.

AIASA STATE CAD COMPETITION GUIDELINES

1. Each state entering the CAD competition shall have a CAD committee of not less than three. The CAD committee may be the same as the existing drafting problems committee, however, there must be representation from both Junior and Senior high schools.

2. Four areas of drawing shall be sanctioned, as follows:
   Level I -- Mechanical (Junior)
   Level I -- Architectural (Junior)
   Level II -- Mechanical (Senior)
   Level II -- Architectural (Senior)

3. Each state committee shall select the drawing for the STATE competition at each level. It shall be allowable to use the same drawing problems or drawing guidelines established for the traditional drawing competition.

4. Any software or hardware may be utilized for the state CAD competition. Hardware and software must be the same configuration used for instruction in the competitor's school.

5. Drawings must be submitted on 18x24 paper and must contain the following information in the title box:

   A. Student's name and grade
   B. Teacher's name
   C. School's name, address and phone number
   D. Manufacturers of the hardware and software used for the drawing
   E. Other standard information required as common drafting practice -- either ANSI or DOD standards.

6. Drawings shall be submitted in hard copy and on diskette. The diskette must be fully labeled with the above information, A through E.

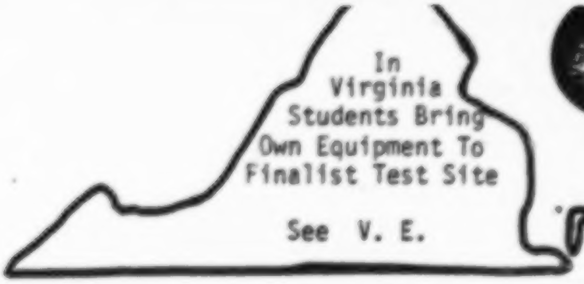
7. Drawings shall be submitted to the state committee no later than March 15, 1987.

8. A first prize winner in each of four categories will be selected by the state committee and their drawings and diskettes forwarded to Autodesk, Inc., postmarked no later than April 1, 1987.

9. With an advisory committee of professionals and drafting teachers, Autodesk will select the top 15 drawings in each category and notify the winning school no later than April 15, 1987. (The 15 finalists will not be ranked.)

10. Autodesk, Inc. will arrange to equip each school with the latest version of AutoCAD and with AutoCAD/AEC for each of the architectural finalists. Instructional workbooks will also be provided. The school is responsible for supplying adequate hardware for the software. (Configurations will be discussed at the time the schools are notified.)

***



In Virginia Students Bring Own Equipment To Finalist Test Site

See V. E.

MODERN SCHOOL SUPPLIES ENGINEERING PROBLEMS

OVERVIEW: AIASA contestants in Modern School Supplies Engineering Problems are required to submit a portfolio of drawings to be judged. The contestants must also complete an objective examination covering the field of drafting.

I. CONTEST PURPOSE

The purpose of the Modern School Supplies Engineering Problems contest is to provide a means for AIASA members to demonstrate their ability to draw technically and to demonstrate their knowledge of drafting.

II. ELIGIBILITY FOR ENTRY

A. Entries are limited to two (2) per chapter.

B. See "General Rules" for additional information.

III. LEVELS OF COMPETITION

Level II as described in General Rules.

IV. LIMITATIONS

A. Engineering drawings in portfolio must be submitted to the Contest Coordinator at the designated check-in time and location.

B. A one-hour drawing test will be conducted for finalists only.

V. SPECIFIC REGULATIONS

A. Each entry will consist of a portfolio of at least five (5) but no more than ten (10) sheets by the contestant.

Architectural drawings shall NOT be put in the entry portfolio for Engineering Problem

B. Drawings may be detail and assembly drawings and/or machine pictorials from the list below.

1. Pictorial assembly drawings of machines or machine parts which involve rendering with air brush, pen, or pencil.
2. Exploded assembly drawings rendered or plain technical illustration.

3. Perspective drawings with one, two, or three vanishing points, such as machine parts, automobiles, etc.
4. Axonometric projections.
5. Computer Aided Drafting (CAD) entries are encouraged but limited to two (2) per entry.

C. Only original drawings may be entered.

D. Answer sheets and paper will be furnished at test site for finalists.

V.E. NOTE:
In Virginia, Students will bring own equipment. Not provided.

E. The following drawing equipment will be provided by the National AIASA: drawing board; T-square; 45-degree triangle; 60-degree triangle; appropriate scale; eraser; eraser shield; lead holder; 2-H, 4-H, and 6-H leads; and drafting kit.

F. Finalists may not take any notes or reference materials into test room.

VI. PROCEDURE

A. Registration

1. Contest participants must register for the event in accordance with procedures established for conference.
2. On-site verification must be completed at Conference Information Desk.
3. Obtain time to set up portfolios from the Competitive Events Coordinator.

B. Competition

1. Place portfolio of drawings in judging room.
2. Judges will rate each entry and post names for finalist test.
3. Judges will grade test papers and return results to Contest Coordinator.
4. Contest Coordinator will tally ratings with test scores.

VII. SUPPLY LIST

A. Personnel

1. Contest Coordinator
2. Judges, three (3)
3. Helpers, three (3)

B. Equipment

1. Contest guidelines (3 per level)
2. Judges' rating sheets
3. Test questions (number based on entries), 10
4. Scantron for grading

5. Current blueprints or drawings to solve problems (number based on entries), 10
6. Marking pens for judges, six (6)
7. Tables and chairs for contestants
8. Table and chairs for judges (3-person workstation)
9. List of entries

C. Supplies

1. Pencils for marking test answer sheets (number based on entries), 10
2. Drawing paper preprinted (number based on entries), 10
3. Answer sheets for test questions (number based on entries), 10
4. Instruction sheet for students (number based on entries), 10

VIII. CRITERIA FOR JUDGING

A. Drawings

Line quality	20 points
Accuracy of details	20 points
Dimensioning accuracy	20 points
Neatness, lettering uniformity, and general appearance	20 points
Subtotal	80 points

B. Drawing Tests for Finalists

10 objective test questions on understanding of engineering drawing and career opportunities	10 points
Problem solution test using drawing equipment	10 points
Total	100 points

CONTEST COORDINATOR INSTRUCTION SHEET

ENGINEERING PROBLEMS

I. CONTENTS

A. Judges' rating sheets
B. Contest guidelines for the Coordinator and the judges
C. Competitive Events Personnel and Contestant/Team Entry List
D. Results envelope
E. Complimentary items for Coordinator and judges

II. PROCEDURES

A. Check the contents of the Coordinator's envelope.

B. Review the contest limitations, regulations, and procedures. Any deviation from the above by any contestant or team shall result in disqualification.

C. Distribute the judges' materials.

D. Review the limitations, regulations, and procedures with the judges. Clear up any questions or misunderstandings.

E. Collect and set up drawings for viewing by judges and assist during judging.

F. Secure the judges' signatures on their rating sheets.

G. Select one judge to assist in completing the summary sheet.

H. Secure the initials of all judges on the competitive event summary sheet after they have all reviewed it. Through the discussion process, the judges shall break any ties that affect the top three (3) placements.

I. Select the top ten (10) to compete with drawing problem.

J. Provide basic drawing set and problem to the top ten (10).

K. Allow 1 hour for solving drawing problem.

L. Issue test.

M. Using the results envelope provided, submit to the Competitive Events Coordinator:

1. Competitive Events Personnel and Contestant/Team Entry List
2. Judges' Rating Sheets

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.

AIASA Engineering Problems

Judge's Official Rating Sheet

Level 2 ONLY

Entrant's I.D. -----> **Judging Criteria**												
Drawings Line Quality 20 pts. max												
Accuracy of Details .... 20 pts. max.												
Dimensioning Accuracy .... 20 pts. max												
Neatness, Lettering Uniformity, and General Appearance .... 20 pts. max												
SUBTOTAL .... 80 pts. max.												
Tests for Finalists Ten Objective Test .... 10 pts. max.												
Problem Solution Test .... 10 pts. max.												
Total .... 100 pts. max.												

I certify these results to be true and accurate to the best of my knowledge and ability.

Judge's Signature

PROBLEM SOLVING TEAM

OVERVIEW: The Problem Solving Team Contest is designed to challenge students to make creative use of tools, machines, processes, and systems of technology in solving problems. A description or "statement of the problem" is sent to each teacher or printed in the Registration Packet for the Technology Education Spring Festival. The team's solution is brought to the Festival and demonstrated or tested fo judges in an area open to spectators. Eight (8) teams are selected for final evaluation. Plaques will be presented at the Awards Program to the top three (3) teams.

I. CONTEST PURPOSE

The purpose of the Problem Solving Team Contest is to develop student creative thinking, and problem solving abilities involving group work, material resources, processes, and technological systems.

II. ELIGIBILITY FOR ENTRY

Each chapter may enter only one (1) team. A team consisting of no less than two (2) chapter members and no more than four (4) chapter members. All students on the team must be from the same Level of Competition.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

The contest team must present and remove the team solution at the time specified in the conference program. The solution will be demonstrated or tested by team members for a time specified by judges of this contest.

V. SPECIFIC REGULATIONS

A. All entries must be turned in at the designated time. The team will be given or assigned a time for demonstration.

B. No revisions to the entry may be made after entry has been placed in holding room.

C. Problem to be solved and rules for entry will be mailed with Registration Packet prior to Spring Festival.

VI. PROCEDURE

A. Team contestants will register for this contest.

B. The Team Leader will present the solution or entry to the Contest Coordinator for storage in the contest holding room.

C. Students on team will report to demonstration area at time assigned for their entry.

D. Solution will be demonstrated and rated by judges.

E. Students will answer "interview" questions posed by judges. (This could be finalist - 8 teams.)

F. Judges will turn in ratings to Accounting Committee.

VII. REQUIRED CONTEST PERSONNEL AND EQUIPMENT

A. Contest Coordinator

B. Judges - three (3) per level

C. Timekeeper - one (1) per level

D. Rooms - one (1) holding room for both levels
with table and chairs for judges
one (1) demonstration room for both levels
with floor space for entries to operate
Space for spectators to watch the solution demonstrations.

VIII. CRITERIA FOR JUDGING

A. The rating sheet for this event will be prepared by judges and mailed with Problem Statement.

B. Points will be earned for use of specified materials and processes.

C. Points will be earned as entry moves toward or achieves each challenge.

D. Judges will give one (1) verbal problem and one (1) performance problem to each of the top eight (8) finalist teams.

D. Judges will rate each problem on creative thinking--ten (10) points for creative solution to verbal problem and ten (10) points for creative solution of performance.

~~Accounting Committee.~~

CONTEST COORDINATOR INSTRUCTION SHEET

B-7 PROBLEM SOLVING TEAM - LEVEL I
B-8 PROBLEM SOLVING TEAM - LEVEL II

I. Contents
   A. Judges' Rating Sheets
   B. Contest Guidelines for the Coordinator and the judges.
   C. List of Competitive Events Personnel.
   D. Ribbons or name badges for judges to wear.
   E. Entry list of teams in Contest B-7 and B-8.
   F. I.D. tags or stick-on tabs to number entries.
   G. Results envelope.

II. Procedures
   A. Check the contents of the Coordinator's envelope.
   B. Review the contest limitations, regulations, and procedures. Any deviation from the above by any contestant shall result in disqualification.
   C. Distribute the judges' materials and ribbons or name badges.
   D. Review the contest limitations, regulations, and procedures with the judges to clear up any questions or misunderstandings.
   E. Check in the contestants at the time printed in the program. Anyone reporting, but not on the Entry List, shall be sent to the Competitive Events Coordinator and shall only be entered upon returning with a note of approval from the Competitive Events Coordinator. Review rules with contestants.
   F. The judges will secure the entries in the area designated by the Competitive Events Coordinator. They will also assist in taking them to the testing room the next day.
   G. The judges will evaluate the entry solution which has been submitted by each team.
   H. The judges will post an appointment schedule for students to run or present their entry solution before the judges and spectators.
   I. The judges will rate the live performance of each entry solution and determine the top ten (10) entries.
   J. The judges will post a schedule when the top ten (10) teams will appear for finalists' evaluation.
   K. Each team will be given one verbal problem and one performance problem. (No spectators allowed.)
   L. The judges will rate each team's solution and determine the 1st, 2nd, and 3rd-place teams.
   M. Using the results envelope provided, submit to the Competitive Events Coordinator:
      1. Competitive Events Personnel and Contestant Entry List.
      2. Judges' Rating Sheet(s).
   N. The entry solutions will be open to viewing by spectators.

SPECIAL NOTE: Only the testing portion of this contest is a spectator event.

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.

PROBLEM SOLVING TEAM CONTEST

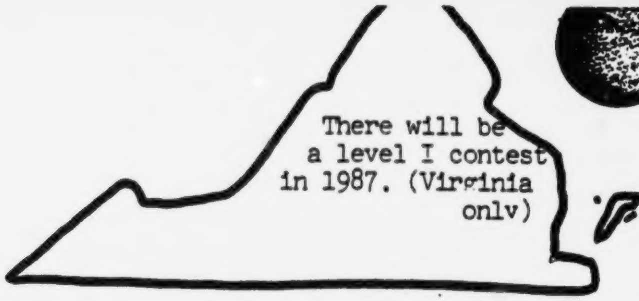
Judge's Official Rating Sheet

Level 1 or 2 (Circle)

Entrant's I.D. -----> **Judging Criteria**												
Check here when problem solution is received and marked with ID number for storage in Holding Room.												
Materials and Processes . . 20 pts. max. used. Up to 20 points will be given for use of materials and/or processes specified in problem statement.												
Solution Rating Points Straightness of travel. . 30 pts. max. Distance of travel. . . . 30 pts. max.												
Up to 60 points will be given for demonstration of solution. Categories will be specified when problem statement is released.												
Sub Total 80 pts. max.												
Finalist Creative Verbal Problem 10 pts Finalist Creative Performance Problem 10 pts												
Total . . . . 100 pts. max.												

I certify these results to be true and accurate to the best of my knowledge and ability.

____
Judge's Signature



There will be a level I contest in 1987. (Virginia only)

RESEARCH PAPER

OVERVIEW: AIASA members entering the Research Paper contest are required to research an Industrial Arts/Technology Education related topic which they select and present a written paper on the topic.

I. CONTEST PURPOSE

The purpose of the Research Paper contest is to provide a means for AIASA members to demonstrate their ability to select a topic, research the topic, and create written communication following an accepted format.

II. ELIGIBILITY FOR ENTRY

Entries are limited to two (2) per chapter.

III. LEVELS OF COMPETITION

The competition is open to Level II students only.

IV. TIME LIMITATIONS

While this is not a "timed" event, all schedules must be adhered to as presented in Sections V and VI.

V. SPECIFIC REGULATIONS

A. The research paper is an individual project. No recognition will be given to a group effort.

B. The introduction, review of related literature, and conclusion shall be limited to ten (10) pages.

Entries shall be submitted with a plain title page as described without any plastic covers, back pages, or any additional pages.

C. Charts, tables, drawings, diagrams, and short reprints of reference material are to be placed in the appendix. The appendix will not count as part of the ten (10) pages of the research paper.

D. A bibliography of ALL references used is to be included. This also will not count as part of the ten (10) pages of the research paper.

E. The basic outline shall include:

Title Page (which must be removable for judging)
Table of Contents
Introduction (include title above the Introduction section)
Review of Literature
Conclusion
Endnotes/Footnotes, if applicable

F. The research paper shall be typewritten, double spaced, on one side of good-quality 8 1/2" x 11" plain white paper.

G. The topic of the research paper may be related to any aspect of Industrial Arts/Technology Education.

H. The title page is to be included at the beginning of the paper, using the following format: (NOTE: The title of the research paper must also be listed at the top of the first page of the research paper.)

TITLE OF PAPER

being

A Paper Entered in the

RESEARCH PAPER CONTEST

by

Put Your Name Here
Home Address

Chapter Name ________________ Level ________________

School Name ________________ Grade ________________

School Address ________________ Entry Number ________________
(assigned by Coordinator)

____

Date ________________________ Approved ________________
AIASA Local Advisor

I. The title page will not count as one of the ten (10) pages of the research paper.

J. Contestants may not have entered this research paper at any previous National Conference.

K. Three (3) copies of the research paper shall be mailed to the Competitive Events Coordinator by the preset deadline date. NOTE: NO ENTRIES WILL BE ACCEPTED THAT ARE POSTMARKED BEYOND THE DEADLINE DATE. (It is advisable to keep an additional copy of the research paper.)

VI. PROCEDURE

A. Registration - Contest participants must register and follow the guidelines for the event in accordance with procedures established for each conference.

B. Research papers must be mailed in by deadline date.

C. No research papers (or copies) may be picked up before the assigned pick-up time.

D. All winning research papers become the property of AIASA, Inc. for a period of one year, to be utilized as deemed appropriate by the corporate board members.

VII. REQUIRED CONTEST PERSONNEL AND EQUIPMENT

A. Contest Coordinator

B. Judges - a minimum of three (3) per level

C. Tables and chairs for judges and Contest Coordinator

VIII. CRITERIA FOR JUDGING

A. Contestants shall be ranked in numerical order on the basis of a final score to be determined by each judge without consultation with each other. The winner will be that contestant whose total score is the highest. Other placings shall be determined in the same manner. In case of a tie, the judges shall consult each other to ascertain the winner.

B. Rating will be based upon the following:

1. Organization — 25 points
   The theme of the research paper should be clearly stated and be supported by all parts of the paper.

2. Evidence — 25 points
   The theme of the research paper should be supported by specific evidence. Materials from research should fit the theme of the paper.

3. Mechanics — 25 points
   Spelling, sentence structure, and paragraphing should reflect standard usage. Research material MUST be endnoted.

4. Topic Selection, Interest, and Originality — 25 points
   The approach, or presentation, should reflect some original thinking by the author on a topic relating to Industrial Arts/Technology Education.

C. Contest Coordinator will provide the Competitive Events Coordinator with a sealed packet containing the results.

D. All judges' ratings and results are to remain confidential.

CONTEST COORDINATOR INSTRUCTION SHEET

RESEARCH PAPER

I. CONTENTS

A. Judges' rating sheets
B. Contest guidelines for the Coordinator and the judges
C. Competitive Events Personnel and Contestant/Team Entry List
D. Results envelope
E. Complimentary items for Coordinator and judges

II. PROCEDURES

A. Check the contents of the Coordinator's box.

B. Review the contest limitations, regulations, and procedures. Any deviation from the above by any contestant or team shall result in disqualification. Pick up the research papers from the Competitive Events Coordinator.

C. Distribute the judges' materials (including the research papers).

D. Review the limitations, regulations, and procedures with the judges. Clear up any questions or misunderstandings.

E. Meet with the judges at the prescribed time and place to begin the judging of the research papers.

F. The chart below assigns which papers are to be read by each judge. After the first reading, the Contest Coordinator will complete a summary sheet and ascertain which entries are finalists. The semi-finalist papers must then be read by all the judges of the contest, and the ranking will be determined from the composite score for the second reading.

1-15 Entries 3 Judges

Divide the entries into thirds
Assign Judge 1 the first and second thirds
Assign Judge 2 the second and third thirds
Assign Judge 3 the third and first thirds

16-25 Entries 4 Judges

Divide the entries into half
Assign Judges 1 & 2 the first half
Assign Judges 3 & 4 the second half

26-35 Entries 5 Judges

Divide the entries into fifths
Assign Judge 1 the first and fifth fifths
Assign Judge 2 the first and second fifths
Assign Judge 3 the second and third fifths
Assign Judge 4 the third and fourth fifths
Assign Judge 5 the fourth and fifth fifths

36-45 Entries 6 Judges

Divide the entries into thirds
Assign Judges 1 & 2 the first third
Assign Judges 3 & 4 the second third
Assign Judges 5 & 6 the third third

G. Secure the judges' signatures on their score sheets.

H. Secure the initials of all the judges on the summary sheet after they have all reviewed it.

I. Using the results envelope provided, submit the items below to the Competitive Events Coordinator. Turn in the judging box.

1. Competitive Events Personnel and Contestant/Team Entry List
2. Judges' Rating Sheets

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.

J. Return all of the research papers to the Competitive Events Coordinator.

(NOTE: Judging has been changed this year. Please follow the above directions and rank all papers. The computer will process your raw scores so you do not need to summarise them. Each judge need only total each of his/her entries.)

AIASA Research Paper

Judge's Official Rating Sheet

Level 1 or 2 (Circle)

Entrant's I.D. -----> **Judging Criteria**												
Organization . . . . 25 pts. max. Clear theme or point, proper order and or sequence, etc.												
Evidence . . . . 25 pts. max. Paper supported by specific evidence, research fits theme or point, etc.												
Mechanics . . . . 25 pts. max. Spelling, sentence structure, paragraphing and properly endnoted/footnoted.												
Topic, Interest, and Originality . . . 25 pts. max. Ind. Arts/Tech. Ed. topic, approach, or presentation reflects originality, interesting reading, etc.												
TOTAL . . . . 100 pts. max.												

I certify these results to be true and accurate to the best of my knowledge and ability

____
Judge's Signature

TECHNOLOGY PROCESS DISPLAY

OVERVIEW: AIASA chapters entering the Technology Process Display contest are required to construct and display an industrial or technological process within a defined area.

I. CONTEST PURPOSE

The purpose of the Technology Process Display contest is to provide a means for AIASA chapters to demonstrate their knowledge of a process which they have researched by fabricating a display of the researched process.

II. ELIGIBILITY FOR ENTRY

A. Only AIASA chapters in good standing are eligible for entry.

B. Each chapter that is eligible may enter one display or exhibit for competition at the national contest level during the annual convention.

C. One entry per level.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

While this is not a "timed" event, all schedules must be adhered to as presented in Sections V and VI.

V. SPECIFIC REGULATIONS

A violation of regulations A or B will disqualify entry.

A. The exhibit size may not exceed 4'x4'x8' high.

B. The exhibit must depict some industry, industrial process, operation, or application of methods or processes used in industry. (Applications of new technology to solve technical problems are encouraged.)

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. Exhibit must be entered during the assigned contest entry time.

C. Contest Coordinator must attach an entry number in the lower right corner of the exhibit. The contest number will be assigned during contest registration.

VII. SUPPLY LIST

A. Personnel

1. Contest Coordinator
2. Judges, three (3) per level
3. Helpers, two (2) per level

B. Equipment

1. Contest guidelines (3 per level)
2. Judges' rating sheets
3. Marking pens for judges, 12
4. Display tables for technology process display (a minimum of 12 4' x 8' tables per level)
5. Table and chair for judges (3-person workstation per level)
6. List of entries

VIII. CRITERIA FOR JUDGING

A. The exhibit must be a chapter project.

B. Each exhibit shall have a description of the industry or industrial process it depicts. The number of chapter members participating in the total exhibit shall also be noted.

C. No students or advisor will be allowed to stand by exhibits during judging.

D. Rating will be based on the following:

Organization	20 points
Originality	20 points
Subject Coverage	30 points
Interest and Appeal	15 points
Workmanship	15 points

CONTEST COORDINATOR INSTRUCTION SHEET

TECHNOLOGY PROCESS DISPLAY

I. CONTENTS

A. Judges' rating sheets
B. Contest guidelines for the Coordinator and the judges
C. Competitive Events Personnel and Contestant/Team Entry List
D. Results envelope
E. Complimentary items for Coordinator and judges

II. PROCEDURES

A. Check the contents of the Coordinator's envelope.

B. Review the contest limitations, regulations, and procedures.

C. Distribute the judges' materials.

D. Review the limitations, regulations, and procedures with the judges. Clear up any questions or misunderstandings.

E. Secure the judges' signatures on their rating sheets.

F. Using the results envelope provided, submit to the Competitive Events Coordinator:

1. Competitive Events Personnel and Contestant/Team Entry List
2. Judges' Rating Sheets

PLEASE IDENTIFY THE CONTEST AND THE LEVEL ON THE FRONT OF THE RESULTS ENVELOPE AND SEAL IT BEFORE RETURNING IT.

G. Secure area containing Technology Process Display.

AIASA Tech. Process Display

Judge's Official Rating Sheet

Level 1 or 2 (Circle)

Entrant's I.D. -----> **Judging Criteria**												
Organization .... 20 pts. max.												
Originality .... 20 pts. max.												
Subject Coverage .... 30 pts. max.												
Interest and Appeal .... 15 pts. max.												
Workmanship .... 15 pts. max.												
Total .... 100 pts. max.												

I certify these results to be true and accurate to the best of my knowledge and ability.

____

Judge's Signature

APPENDIX K

EVALUATION TECHNIQUES

Sample Items for Student Feedback Instruments

In order to evaluate whether students have achieved the performance objectives of the "Introduction to Engineering" course, a number of different types of feedback instruments should be used. The instrument with greatest fidelity would be a problem-oriented design project that involves students in the application of engineering concepts and techniques. Sample A of this section provides an example that deals with the design of a solar collector. In order to carry out the project, students have to make use of the elements of design and decision-making that is outlined.

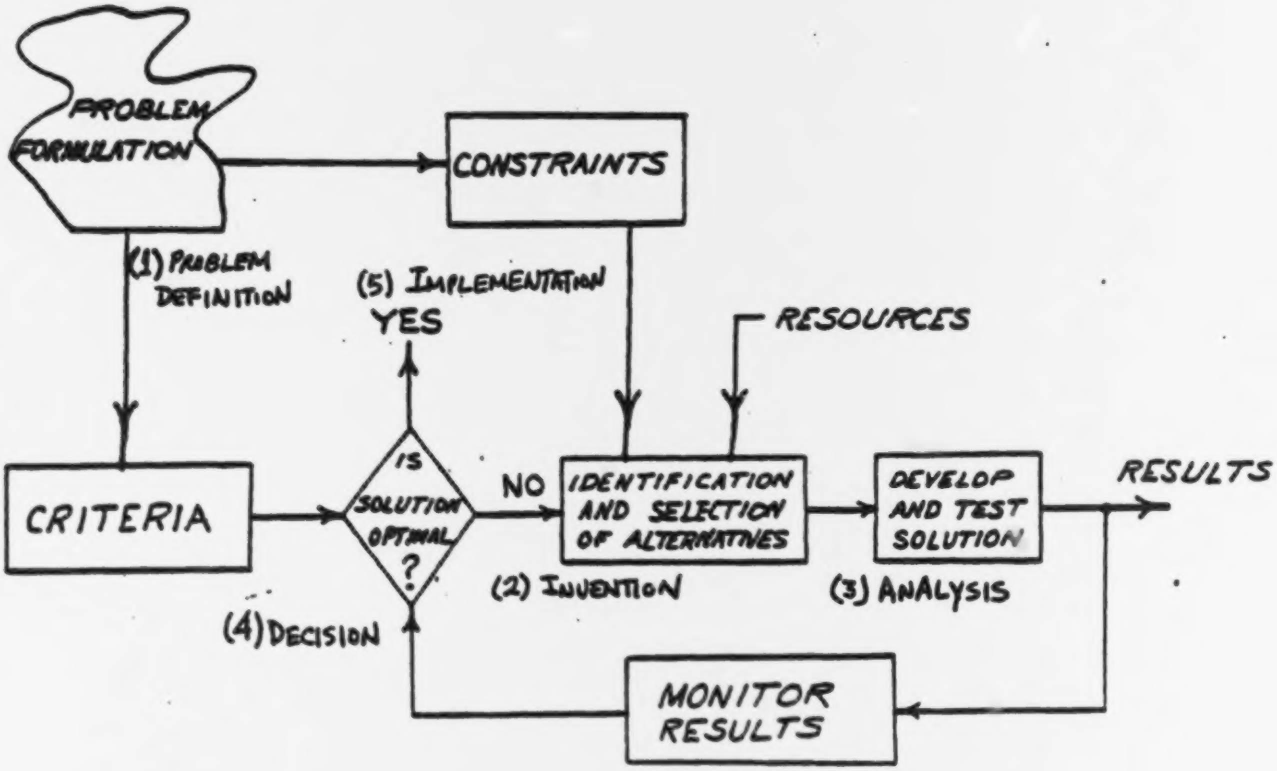
After the completion of this course, it is also important to assess the general readiness of the students for college engineering studies. Sample B is a practice test that is modeled after the Minnesota Engineering Analogies Test (MEAT).

Periodic quizzes and examinations should also be given to monitor student progress in the course. Question formats should include multiple choice, short essays, and word problems. Sample C is a final examination that was used in a freshmen engineering course as concrete examples of the type questions that can be used. When designing test items, there must be a clear match between performance objectives and test questions.

Sample teacher prepared problem solving tests are illustrated in samples D and E.

GUIDELINES FOR ENGINEERING DESIGN PROJECT

(I) Overview: your term project should involve the design, construction, and testing of a device or system for solving a technology-based problem. The following engineering approach to problem-solving should be applied:


PROBLEM FORMULATION
CONSTRAINTS
(1) PROBLEM DEFINITION
(5) IMPLEMENTATION
YES
RESOURCES
CRITERIA
IS SOLUTION OPTIMAL ?
NO
IDENTIFICATION AND SELECTION OF ALTERNATIVES
DEVELOP AND TEST SOLUTION
RESULTS
(2) INVENTION
(3) ANALYSIS
(4) DECISION
MONITOR RESULTS

(II) Project Outline:

1. General Problem Description
2. Criteria
3. Constraints
4. Resources
5. Potential Solutions to be Explored

(III) Final Report Should Include:

1. Revised project outline
2. Description of final design (with diagrams) with performance information
3. Description of the process of optimization

Engineering Design Project and Contest: Solar Collector

(I) **Design Criterion**: The objective is to design a system for heating water with solar energy. The criterion is to design a solar collector that can heat a cup of water to the highest temperature.

(II) **Constraints**: The prototype solar collector must be designed within the following limitations:

(1) Maximum size: 1000 cm^3
(2) Maximum cost of materials: $5.00
(3) Maximum mass: ½ kg
(4) The amount of water to be heated is 200 ml(gram)

(III) **Alternative Designs**:

(1) Flat plate collector systems
(2) Concentration collector systems
(3) Photovoltaic collector systems

(IV) **Factors that affect the performance of solar collector systems**:

(1) Solar radiation variables, include energy and power densities and position of the sun.
(2) Collector variables include color of absorber, "greenhouse" phenomena, and type of insulation.

(V) **Optimization**: Analyze the factors that affect the performance of solar collectors and design a collector system that will:

(1) collect the most solar energy that can be used to heat water.
(2) prevent the heated water from losing heat to its surroundings.

Improvements in collector design should be based on testing of alternative design concepts. Keep a log of your design changes to include in your final report.

(VI) **Contest Procedure**: Each collector will be left in the same sunlight for 30 minutes. The collector system that causes 200 ml of water to raise to the highest temperature will be the winner.

SAMPLE B

Minnesota Engineering Analogies Test (MEAT)

Practice Test

DIRECTIONS: In each of the following questions, the analogies are presented in the A:B :: C ______ format. For example: Oak:tree :: iron: ______ (1) compound (2) element (3) steel (4) rust.

Element, number 2 of the four choices, is the correct answer because element is related to iron in the same way that tree is related to oak. Iron is a type of element and oak is a type of tree. You have an unlimited period of time to complete this 50-item test. To record your answers, you may use either the answer space provided next to each question or the Answer Sheet on page ______.

(1) America:Columbus :: Photoelectric emission of electrons: ______
(1) Planck (2) Einstein (3) Röntgen (4) Compton

(2) Beta radiation:Electrons :: Gamma radiation: ______
(1) Protons (2) Neutrons (3) Helium atoms (4) Electromagnetic waves

(3) $3x^2:6x :: 5y:$ ______
(1) 5 (2) 10 (3) y (4) 10y

(4) Displacement:Velocity :: y: ______
(1) derivative (2) rate of change (3) $\frac{dy}{dx}$ (4) momentum

(5) A falling object accelerates uniformly at 9.8m/sec ^{2}.
Speed after 1 second : 9.8m/sec :: Distance after 1 second : ______
(1) 9.8m (2) 4.9m (3) 19.6m (4) 1m

(6) Frequency:Period :: Hertz: ______
(1) seconds (2) minutes (3) hours (4) days

(7) Assume that a person is visiting different planets.
Variable:Constant :: Weight: ______
(1) Atmosphere (2) Sun (3) Size (4) Mass

(8) Light in vacuum : 3×10^8 m/sec :: sound in air : ______
(1) $\approx 3.3\times10^1$ m/sec (2) $\approx 3.3\times10^2$ m/sec (3) $\approx 3.3\times10^3$ m/sec (4) $\approx 3.3\times10^4$ m/sec

Explanation of Answers for the MEAT Practice Test

(1) Answer (2) Columbus discovered America while Einstein discovered that photons of light with sufficient amounts of energy can cause an electron to be emitted from the surface of a material.

(2) Answer (4) Beta radiation is made up of electrons which have a negative charge. Gamma radiation is made up of high frequency electromagnetic waves.

(3) Answer (1) $6x$ is the derivative of $3x^2$ and 5 is the derivative of $5y$.

(4) Answer (3) Velocity is the first derivative of displacement.

(5) Answer (2) $V = at \therefore V = 9.8\ \text{m/sec}^{\cancel{2}}\ (1\ \cancel{\text{sec}}) = 9.8\ \text{m/sec}$

$$D = \tfrac{1}{2}at^2 \therefore D = \frac{9.8\ \text{m}/\cancel{\text{sec}^2}(1\ \cancel{\text{sec}^2})}{2} = 4.9\text{m}$$

(6) Answer (1) Frequency is measured in hertz or cycles/second. Therefore, Period ($1/f$) is measured in seconds.

(7) Answer (4) The weight will vary because it depends on the pull of gravity of each planet. However, the mass will remain constant because it is a measure of the amount of material in a substance.

(8) Answer (2) Speed of light in vacuum is 3×10^8 m/sec while the speed of sound in air is $\approx 3 \times 10^2$ m/sec.

(9) Answer (3) Newton is a unit of force that is defined by the equation $F = ma = \text{Kg m/sec}^2$. A farad is a unit of electrical capacitance that is defined by the equation $C = Q/V = \text{coulomb}/\text{volt}$.

(10) Answer (2) The capacitive reactance (X_C) is computed by the equation: $X_C = \frac{1}{2\pi FC}$ and the inductive reactance (X_L) is computed by the equation: $X_L = 2\pi FL$.

(11) Answer (1) Feedback that is negative causes a system to achieve a desired goal and thus stability is achieved. On the other hand, feedback that is positive causes a system to deviate from its desired goal resulting in an unstable condition.

(12) Answer (3) The telegraph was replaced by the telephone, and the vacuum tube was replaced by the transistor.

FINAL EXAMINATION

PART I - MULTIPLE CHOICE QUESTIONS

Select the most appropriate answer from the choices.

Questions 1-7 Directions: In each of the following questions, the analogies are presented in the A:B :: C:____ format. For example: Oak:tree :: iron: ____ (1) compound (2) element (3) steel (4) rust.

Element, number 2 of the four choices, is the correct answer because element is related to iron in the same way that tree is related to oak. Iron is a type of element and oak is a type of tree.

1) Energy:Power :: Distance:____ (a) Work (b) Speed (c) Displacement (d) Force

2) Battery:Flywheel :: Chemical Energy:____ (a) Mechanical Energy (b) Heat Energy (c) Potential Energy (d) Nuclear Energy

3) A 100-watt bulb is on for 10 hours. Power:100 watts :: Energy:____ (a) 10 kilowatt-hours (b) 1 kilowatt-hour (c) 100 watt-hours (d) 10 watt-hours

4) Fusion:Fission :: Combination:____ (a) Compound (b) Mix (c) Radioactivity (d) Split

5) A pot containing 2 kilograms of water is heated from 20°C to 30°C. Change in temperature:Heat gained :: 10°C:____ (a) 10 kilocalories (b) 10 BTUs (c) 20 kilocalories (d) 20 BTUs

6) In the design of a binary adder; Carry Digit:And Gate :: Sum Digit:____ (a) Nor Gate (b) Inclusive Or Gate (c) Exclusive Or Gate (d) Nand Gate

7) Binary:Octal :: 1010:____ (a) 11 (b) 12 (c) 13 (d) 14

8) Which of the following must be considered in order to evaluate whether electric vehicles can substitute for gasoline-powered vehicles? (a) Range (b) Acceleration (c) Maximum speed (d) All of the above

9) A major disadvantage of lead-acid storage batteries is that (a) the energy density of lead-acid batteries is very low (b) they contain less explosive capability per kg. (c) the acid in the batteries is poisonous (d) they emit highly toxic gasses.

10) The economics of solar heating as indicated by the length of the "payback" period should improve in the future due to (a) a decrease in the cost of installing solar heating equipment (b) significant improvement in home construction (c) an increase in the cost of present fuels (d) an increase in home handyman units.

11) A solar collector is located at 41° North latitude. It is tilted at an angle of 30° to the horizontal and faces due South. Which one of the following would increase the annual energy collected? (a) Paint it a lighter color (b) Orient it so that it faces East (c) Move it to 60° North latitude (d) Increase the angle of tilt to 50°.

12) The primary difference between passive and active solar energy systems is that (a) passive systems don't require hardware (b) passive systems don't require an external source of energy (c) active systems have circulating fluids (d) active systems are more expensive.

13) In the 1980s, the primary use of solar energy has been for (a) producing electricity for homes (b) producing electricity for industry (c) hot water and space heating (d) thermal energy for industry.

14) Companies such as LILCO are encouraging the development of electric vehicles because (a) they perform better than gasoline cars (b) they can use off-peak electricity (c) they are easier to maintain (d) they are good for stop and go driving.

15) In order to simulate the behavior of a system on a computer, you must have (a) a mathematical model relating system variables (b) an analog computer (c) a microcomputer (d) instructions for the user of the program.

16) Which two of the EST 192 assignments involve consideration of human factors (ergonomics)? (a) Building Accessibility for the Disabled and Human Power (b) Human Power and Yellow Light (c) Yellow Light and Building Accessibility for the Disabled (d) All of the above.

17) Which of the following is not a unit of power? (a) calorie (b) watt (c) joules/sec (d) ft-lbs/sec.

18) In BASIC, the two commands that relate to the input of data are (a) LET and INPUT (b) INPUT and READ/DATA (c) READ/DATA and PRINT (d) INPUT and PRINT.

(19-20) Digital computers function as a result of the interaction of five subsystems, namely: (1) INPUT unit (2) OUTPUT unit (3) MEMORY unit (4) ARITHMETIC unit (5) CONTROL unit.

19) Design of which two subsystems involve ergonomic considerations? (a) 1 and 2 (b) 1 and 3 (c) 2 and 4 (d) 3 and 5.

20) In modern computers, which two subsystems have been combined to form the CPU (Central Processing Unit)? (a) 1 and 3 (b) 2 and 4 (c) 3 and 4 (d) 4 and 5.

21) The 19th century Jacquard loom was an early precursor of which aspect of modern computers? (a) Use of integrated circuits (b) Use of high resolution graphics (c) Use of high level languages (d) Use of stored programs.

22) Which of the following is not a feature of a program written in assembly language? (a) Must be translated by an assembler before it is executed (b) Machine independent (c) Usually executes faster than a corresponding program in a high-level language (d) More difficult for a beginner to program than most high-level languages.

23) The ASCII code is a: (a) means of setting up a correspondence between characters and groups of binary digits (b) computer programming language (c) a set of assembly language mnemonics (d) a method for guaranteeing the security of computer systems.

24) Considerations of how to direct the system to add a number stored in a memory location to the number in the accumulator is likely to be of least interest to a person (a) programming in machine language (b) programming in assembly language (c) programming in BASIC (d) designing a computer system.

25) The technique of viewing a programming problem as interconnected subproblems as a first attempt in solving the problem may be viewed as (a) top-down programming (b) bottom-up programming (c) unstructured programming (d) programming in a high-level language.

PART II - SHORT ESSAY QUESTIONS

(I) When studying the performance of mechanical systems, Newton's three laws of motion are often used.

(A) Describe how Newton's 1st law of motion is used to explain why seat belts are needed?
(B) Explain how Newton's 2nd law can be used to determine how the mass of a car affects its ability to accelerate?
(C) Use Newton's 3rd law to explain why a car can't accelerate on an icy surface?

(II) Emerging technologies such as modern electric cars and solar energy systems will be used widely only if they can compete with the technology that they are designed to replace. Public acceptance will occur if both the cost is competitive and the performance is improved.

(A) 1) Describe one method of improving the range of electric cars.
2) Discuss one development that would make electric cars more competitive economically.
(B) Two types of solar systems are:
o solar hot water system
o photovoltaic system
1) Describe the energy transformation that takes place in each system and compare the efficiency of the two systems.
2) Which system is more or less cost/effective? Why?

(III) Can solar energy be used to power electric cars? The solutions to the following problems will help you answer this question.

(A) Given: Energy density of batteries is 35 watt-hrs/$_{kg}$
Mass of bank of batteries is 200 kg

How much energy is needed to fully charge this bank of batteries? (Show all work).
(B) On a sunny day if the average solar power density over a 7-hour period is 500 watt/$_{m}{}^{2}$, how much electrical energy will be produced by 2 square-meters of photovoltaic cells that are 10% efficient? (Show all work).
(C) What percent of the total required battery energy [from III (A)] will the photovoltaic system [as used in III (B)] provide?

(IV) Anyone who has flown in a commercial jet airplane is used to such statements as "the airplane is now cruising at 38,000 feet." Though this information is useful, one may still want to know what the altitude is in miles.

Complete the following BASIC program that is designed to print an altitude conversion table for 0 to 100,000 ft. in steps of 10,000 feet. (Remember 5,280 feet = 1 mile).

```
100 REM ALTITUDE CONVERSION
110 PRINT "ALTITUDE", "ALTITUDE"
120 PRINT "IN FEET", "IN FEET"
130 FOR F=0 TO _____ STEP _____
140 __________
150 PRINT F,M
160 __________
170 END
```

1ST ANNUAL WEIGHT DROP

SAMPLE D

ASSIGNMENT

YOU ARE TO DESIGN & CONSTRUCT AN EGG PROTECTING APPARATUS COMMONLY REFERRED TO AS AN EGG PROTECTOR . YOU ARE TO FOLLOW THE RULES LISTED BELOW TO EXACT SPECIFICATIONS. ANY DEVIATION FROM THE RULES WILL RESULT IN YOU "GETTING EGG EVERYWHERE"! JUST A LITTLE SMASHING EXPERIENCE !

REQUIREMENTS

1. STRUCTURAL MEMBERS - TOOTHPICKS (Either round or flat)
   NOT TO EXCEED 3 BOXES (2,250 quantity)

2. ADHESIVE MATERIAL - ELMER'S WHITE GLUE

3. SIZE SPECIFICATIONS -
   - a. Base - wood material not to exceed 12" square.
   - b. Structure Height - not to exceed 12"
   - c. Structure Width - as wide as you desire

4. TESTING PROCEDURES -

   A. 7 POUND BALL will be dropped through a plastic plumbing tube (15' long).

   B. You will be give a choice as to which method of protecting the egg you desire:
      1. DEFLECTING THE WEIGHT (good luck !)
      2. DEFLECTING THE EGG (almost as hard !)

   C. Your structure is to have a resting place for the egg directly under the tube.

   D. The weight will be dropped directly on the egg, you are to protect the egg by kicking it out of the way mechanically with toothpicks or deflecting the force of a 7 pound ball falling at a distance of 15'. (calculate the force of impact of the weight to get a shock)

   D. GRADING PROCEDURES :

      1. A+ (No external damage to the egg shell)
         (No wise cracks!)

      2. C+ (External lacerations of the egg shell)
         (No seepage through lacerations)

      3. F+ (TOTAL ANNIHILATION of the egg)
         (Scrambled eggs)

      4. EACH STUDENT WILL BE GIVE ONE ATTEMPT ON FEBRUARY 19, 1987 DURING 2ND PERIOD.

      5. ALL FAILURES WILL BE GIVEN (1) WEEK TO RECONSTRUCT, if possible, THEIR STRUCTURES.

      6. SECOND & FINAL ATTEMPT WILL BE HELD ON THE FOLLOWING WEEK.

SAMPLE D
Continued

WEIGHT DROP DATA SHEET

WEIGHT DATA

TYPE OF WEIGHT USED : ____________________

HEIGHT OF WEIGHT : ______________cm.

WIDTH OF WEIGHT : _______________cm.

WEIGHT OF WEIGHT USED :________grams

FALLING DISTANCE : 15' or ______meters

SPEED OF WEIGHT : _______meters/sec. or _____mph

IMPACT FORCE OF WEIGHT : _____________

TOOTHPICK DATA

MODULUS OF ELASTICITY OF TOOTHPICK : _________# / SQ. IN.

MODULUS OF RUPTURE OF TOOTHPICK : ____________# / SQ. IN.

FLEXURE OF TOOTHPICK : ____________________ # / SQ. IN.

COMPRESSION OF TOOTHPICK : _______________# / SQ. IN.

TENSION : _________________________________# / SQ. IN.

BEARING : _________________________________# / SQ. IN.

MID-TERM EXAM

SAMPLE E

DATE 1 / /87 PERIOD 5 NAME ____________________

I. PROBLEM:

Design, sketch, draw, and build a bridge that will span a distance of six (6) inches and will be able to support a "Matchbox" car through-out the length. The car must start on an abutment and travel the length of the bridge to the other abutment. There must be a superstructure and/or substructure, i.e. it should look like a bridge and not a slab or tunnel. A sag of more than 0.25 inch will be considered a bridge structural failure.

GIVEN:

1 sheet graph & 1 sheet regular paper- For sketch & drawing
Drafting equipment
2 sheets of 8.5 x 11 paper (93.5 Sq.In./Sht.) for const.
  (try to use less than one sheet)
1 foot of masking tape on plastic
cutting board if needed to protect work surface
scissors
X-O knife or single edge blade
1 "Matchbox" car?- weight 1.5 oz. (which belongs to my son
  and you will replace at a cost of $2.50 if damaged)

GUIDELINES: (READ these very CAREFULLY)

Make sketches on graph paper Hint: Remember strongest
  geometric shapes. Include Name and Date
Drawing done with equipment- Scale 12"=1'-0"
  Front and side view required-- top view optional
  Title:(EXAM BRIDGE)(YOUR NAME)(DATE)(12"=1'-0")
  Use 1/8" guidelines 1/2" up from bottom.
The abutments shall be 6" apart.
The roadway should be a min. of 1.5" / with 2.5" max.
There should be side rails with a 0.5" height
Tape pieces shall be a max. of .75" in length,
  spaced 1.5" apart on any span. Hint: Use narrow
  1/8" strips whenever possible.
Only two (2) layers of paper may be in contact at any one
  point except at single point contacts where braces or
  trusses are attached.
Tape used to attach bridge to abutment shall be no more than
  a single 1/8" strip.
Substructure may touch abutments but not work surface.

Consideration will be given to the amount of tape and paper returned. YOU must calculate the # of square inches of paper remaining* and measure the length of tape remaining. Write your name and # of sq. ins. on the construction paper and turn it in with the remaining tape, your bridge with name on it, your sketch and drawing, the car, and construction equipment.

GRADE WEIGHTS: *= 1 whole and/or 1 partial sheet

Sketch	10%	(show initial thru final planning stage)
Drawing	20%	(accuracy,linework,lettering,& neatness)
Bridge	30% to 45%	(30+ =meets guidelines but exp. failure)
Returned Paper	10%	(must show calculation -remaining sq.in)
Returned Tape	5%	(write length on ret.pa. & name on tape)
Question	10%	(relate Engineer to each of three areas)